



Improvements to Existing Onsite Sanitation Systems: Demonstrations of Technologies

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IMPROVEMENTS TO EXISTING ONSITE SANITATION SYSTEMS: DEMONSTRATIONS OF TECHNOLOGIES

November 2025

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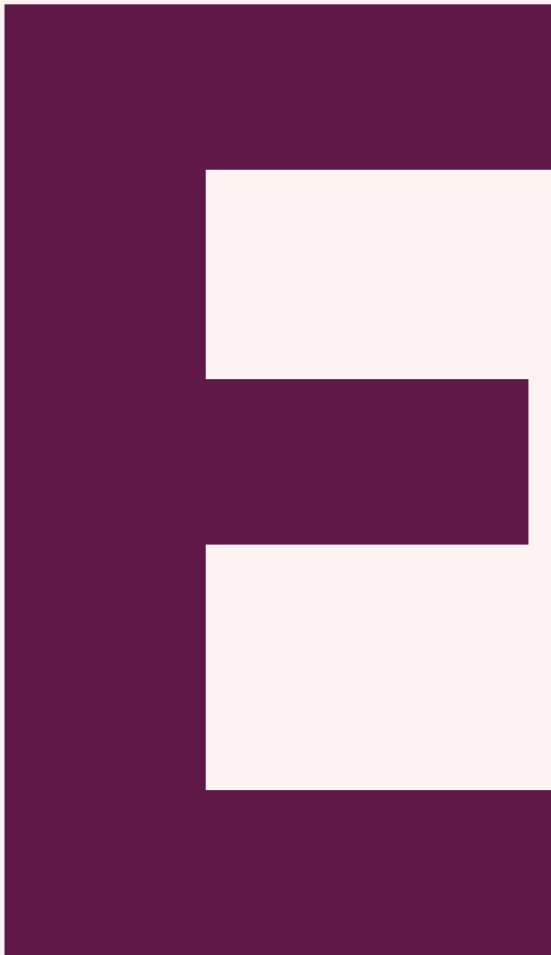
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Abbreviations

ABR	Anaerobic Baffle Reactor
AF	Anaerobic Filter
BIS	Bureau of Indian Standard
BOD	Biological Oxygen Demand
BOQ	Bill of Quantity
COD	Chemical Oxygen Demand
CT	Community Toilet
CTS	Chlorine Tablet System
DRDO	Defence Research and Development Organisation
DSO	De-sludging Operators
E. coli	Escherichia coli
EBR	Earthworm-based Bioreactor
FRP	Fiber Reinforce Plastic
HRT	Hydraulic Retention Time
IHHL	Individual Household Latrine
IHHT	Individual Household Toilet
IS	Indian Standard
KLD	Kilo Litres per Day
LCC	Life Cycle Cost
O&M	Operation & Maintenance
OSS	Onsite Sanitation System
PCC	Plain Cement Concrete
PVC	Poly Vinyl Chloride
PWD	Public Works Department
RCC	Reinforced Cement Concrete
SOR	Schedule of Rates
SRT	Solids Retention Time
TCC	Tiruchirappalli City Corporation
TN	Total Nitrogen
TNUSSP	Tamil Nadu Urban Sanitation Support Programme
TP	Total Phosphorous
TSS	Total Suspended Solids
UGD	Underground Drainage
ULB	Urban Local Body

Executive Summary



Executive Summary

E1.1 Introduction

The report, Improvements to Existing Onsite Sanitation Systems: Demonstrations of Technologies, documents a comprehensive assessment and intervention carried out under the Citywide Inclusive Sanitation (CWIS) programme, led by the Indian Institute for Human Settlements (IIHS), in collaboration with the Tiruchirappalli City Corporation (TCC) and supported by the Gates Foundation. The initiative focuses on upgrading existing Onsite Sanitation Systems (OSS) in Tiruchirappalli (Trichy) to make them safer, more sustainable, and more inclusive, especially for low-income settlements.

E1.2 Context

Tamil Nadu is one of India's rapidly urbanising states, with an urban population of 35 million (Census 2011), which is nearly 48.5 per cent the total population, living in towns and cities. In a majority of these cities and towns, including in Tiruchirappalli (Trichy), OSS remain the dominant mode of waste containment. However, a 2016 TNUSSP baseline survey revealed that the majority of OSS, such as septic tanks, pits, and holding tanks, were poorly designed and constructed, with little adherence to Indian Standard (IS) 2470 norms. This has resulted in groundwater contamination, unsafe effluent discharge, and significant public health risks.

Recognising this, the CWIS programme set out to assess the state of OSS in the city, identify practical and affordable improvement measures, test them through pilot demonstrations, and evaluate their potential for replication and scale-up across Tamil Nadu.

E1.3 Objectives and Approach

The study aimed to,

- Assess the design, construction, and functionality of existing OSS and disposal systems.
- Identify improvement measures that comply with IS 2470 standards.
- Demonstrate feasible technologies at household and bulk generator levels.
- Analyse performance, cost, and user feedback to guide state-wide replication.

The approach combined technical assessment, pilot implementation and monitoring. A five-step methodology was followed: baseline data collection, gap identification, technology selection, field demonstration, and performance monitoring. Laboratory testing assessed Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), nutrients, and E. coli levels to gauge effluent quality before and after interventions.

E1.4 Findings from Assessment

The baseline assessment confirmed that most containment systems were non-compliant with IS standards due to improper sizing, poor construction, and inadequate operation and maintenance. Contributing factors included limited space, low awareness among masons and builders, weak enforcement of building rules, and households' unwillingness to invest in periodic de-sludging.

E1.5 Demonstrated Technologies and Results

To address these gaps, the project implemented 13 household-level and two bulk generator-level demonstration models, ranging from minor retrofits to full system replacements.

At the household-level, five improvement options were tested:

1. IS 2470-compliant septic tank retrofits improved effluent quality and extended de-sludging intervals from six months to two years.
2. Prefabricated Reinforced Cement Concrete (RCC) septic tanks proved quick to install, durable and cost-effective, particularly for low-income households.
3. Earthworm-based Bioreactors (EBR) were conceptually strong but operationally challenging under anaerobic or flood-prone conditions.
4. DRDO biodigesters with patented bio-culture offered compact, odour-free containment systems requiring minimal maintenance.
5. Chlorine Tablet disinfection Systems (CTS) provided an affordable and effective add-on for treating effluent before discharge, reducing E. coli to nearly zero.

At the bulk generator-level, two models were piloted: an improved septic tank system and an EBR with digester. These systems demonstrated the feasibility of decentralised containment improvement, but required careful management to ensure consistent performance.

E1.6 Financial and Operational Insights

The capital costs (CapEx) of the demonstrated systems ranged from INR 2,000–INR 4.5 lakh, depending on the technology and scale, while annual operating costs (OpEx) ranged from INR 2,000–INR 15,000. Life-cycle costs (LCC) varied from INR 19,000 for chlorine systems to INR 8.83 lakh for large biodigesters. These figures indicate that safe, improved sanitation can be achieved at manageable costs if technologies are appropriately matched to site conditions and user capacity.

E1.7 User Experience and Acceptance

Households that participated in the demonstrations reported significant improvements in sanitation conditions, including reduced odour and overflow, and lower maintenance needs. The extended de-sludging intervals and better hygiene generated growing interest from other households, suggesting strong potential for community-level adoption.

E1.8 Challenges

Despite the technical success of most models, several challenges persisted, including shortage of trained masons and de-sludging workers, absence of safety measures during containment work, difficulty in assessing old structures, and user willingness. Additionally, standardisation and regulation of prefabricated units remain critical for ensuring quality and scalability.

E1.9 Lessons Learnt

The demonstrations highlight that prefabricated RCC tanks and DRDO biodigesters hold the greatest potential for replication due to their affordability, ease of installation, and public acceptability. Nature-based systems such as EBRs require further research and design adaptation before wider application.

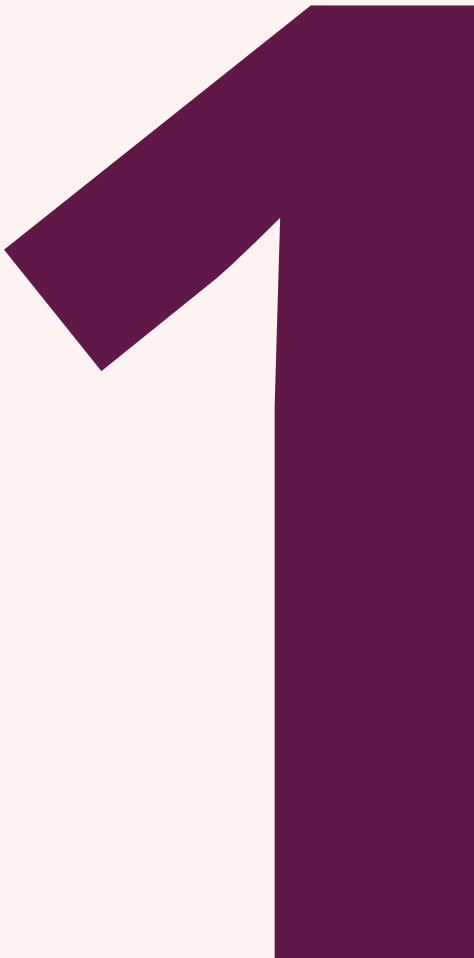
The intervention highlights that technological improvements must be supported by institutional mechanisms, including enforcement of building codes, capacity-building for sanitation workers and masons, certification of OSS technologies, and alignment with state programmes.

E1.10 Way Forward

The pilot interventions demonstrate that inclusive and sustainable sanitation improvements are achievable at scale when technology is combined with community engagement and municipal support. For Tamil Nadu, institutionalising the successful OSS models within policy frameworks, strengthening local manufacturing supply chains, and implementing regular monitoring and certification can enable statewide adoption. This report establishes a clear roadmap for transitioning from unsafe, fragmented OSS toward safe, inclusive, and citywide sanitation.

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1. Background

1.1 Introduction

Launched in 2016, the Citywide Inclusive Sanitation (CWIS) framework represented a fundamental shift in the way urban sanitation is conceived, planned, and delivered. Developed by a global coalition—including the Gates Foundation¹, World Bank, WaterAid, and Emory University—CWIS promotes equitable, safe, and sustainable sanitation for all urban residents, particularly the poor and marginalised. It advocates a systems approach that integrates sewered and non-sewered solutions, and addresses the entire sanitation chain—from containment to reuse or disposal.

In 2018, Tiruchirappalli (Trichy)—a city of over one million people in Tamil Nadu—was selected by the Gates Foundation as one of eight global cities to pilot the CWIS framework. This selection was built on Tamil Nadu's growing momentum in urban sanitation, shaped by the state's flagship mission, 'Muzhu Sugadhara Tamizhagam', and the work of the Tamil Nadu Urban Sanitation Support Programme (TNUSSP). From 2018 to 2024, the Indian Institute for Human Settlements (IIHS), in partnership with the Tiruchirappalli City Corporation (TCC) and a consortium of local partners, led the implementation of the CWIS Trichy Programme with the support of the Gates Foundation. The programme sought to demonstrate how inclusive, citywide sanitation could be delivered at scale through an integrated approach.

Its key objectives were to:

1. Ensure safe management of fecal sludge across the entire sanitation chain
2. Improve service delivery for the urban poor and other vulnerable populations
3. Strengthen the capacity of local governments and communities
4. Integrate gender equity across sanitation planning and service delivery
6. Enhance the well-being and dignity of sanitation workers
7. Position Trichy as a knowledge hub for inclusive sanitation

Collectively, these objectives reflect a commitment to system-wide transformation, bringing together infrastructure, governance, and community engagement to deliver inclusive and sustainable sanitation outcomes. This report is part of a broader series documenting the lessons, challenges, and insights from the CWIS Trichy experience.

1.2 Background of the Study

According to the Census 2011, 81 per cent of households in Trichy had access to individual toilets, and about 45 per cent of them were connected to piped sewer system. According to the baseline study conducted by TNUSSP (2016), among 1500 households surveyed, 41 per cent relied on Onsite Sanitation Systems (OSS), of which nearly 90 per cent were connected to septic tanks and the rest used other systems such as single and twin pits. In addition, the Tiruchirappalli City Corporation (TCC) manages more than 400 Public Toilets (PT) and Community Toilets (CT), of which 270 were connected

¹ The organisation was formerly known as Bill and Melinda Gates Foundation (BMGF).

to the underground sewerage system, while the remaining 130 are equipped with septic tanks for fecal sludge disposal.

Given the predominant use of OSS in the city, the CWIS team carried out an assessment to evaluate the compliance of existing containment and disposal systems of individual households as well as bulk liquid waste generators with relevant standards, and to identify key limitations. Building on these findings, the TCC, with technical support from TNUSSP's Technical Support Unit, identified 36 Community Toilet septic tanks for demonstration of containment improvement interventions. These demonstrations were subsequently used to assess the cost implications and practical challenges associated with construction, and operation and maintenance (O&M) of improved containment systems.

1.3 Need for the Study

Tamil Nadu's urban sanitation landscape is characterised by a high dependence on on-site sanitation systems (OSS), particularly in cities such as Tiruchirappalli. Previous studies—most notably the TNUSSP Baseline Assessment (2016) highlighted that OSS across urban areas in the state often vary widely in design, sizing, and construction quality. The baseline further noted that many containment structures did not fully align with recommended standards such as IS 2470, largely due to inconsistent construction practices, lack of technical oversight, and limited awareness among households and masons.

In Tiruchirappalli, preliminary consultations with the City Corporation and a review of secondary data indicate similar concerns. However, there is currently no comprehensive, city-wide assessment detailing the extent of OSS design deviations, the number of structures affected, or variations across households, bulk waste generators, and community/public toilets. This lack of reliable, up-to-date data makes it difficult to prioritise interventions, plan improvements, or guide future investments.

Given this context, the present study was initiated to systematically assess existing OSS in selected locations across the city, identify common design and operational gaps, and generate evidence-based recommendations for improving containment systems. The following section outlines the typical issues associated with unscientifically designed OSS, drawing on insights from earlier state-level studies and technical guidelines.

These factors collectively contribute to suboptimal system performance and pose potential environmental and public health risks. Some of the typical issues due to unscientifically designed OSS are:

1. Poor effluent quality
2. Deterioration of the disposal system due to flushing of solids
3. Odour nuisance due to inadequate or absence of gas ventilation system

CWIS initiated a detailed study to understand the abovementioned issues, and to identify appropriate interventions to address them.

1.4 Objectives of the Study

The following are the specific objectives of the study:

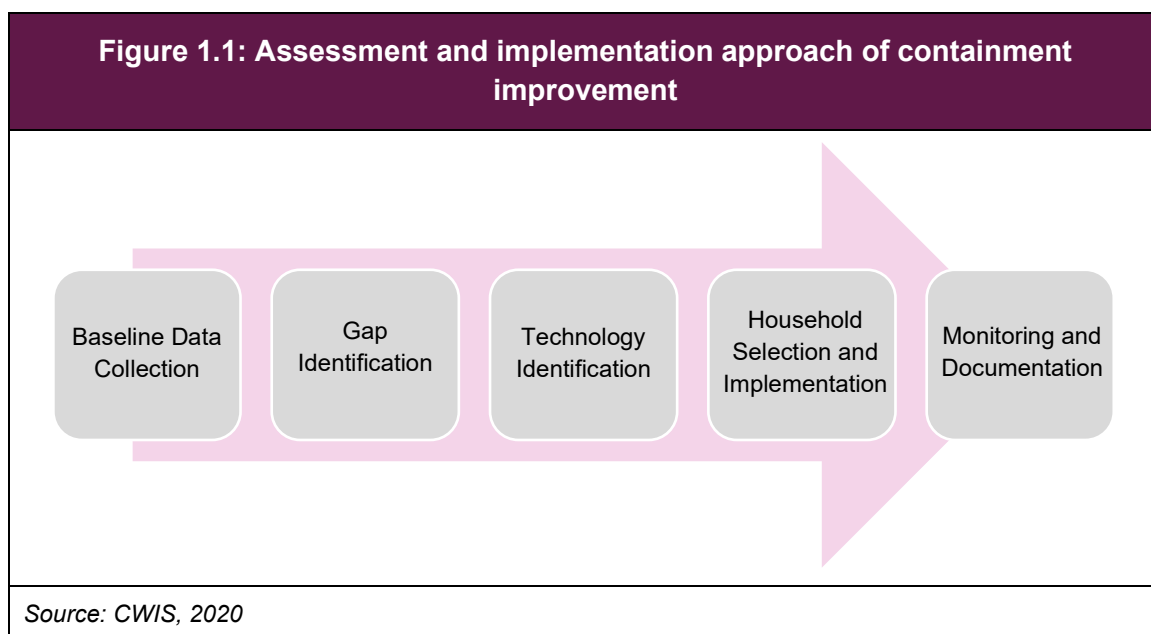
1. To understand the design, construction specifications and related conditions of existing containment and disposal systems.

2. To propose containment improvement measures complying with the standard design and construction recommendations to suit the location.
3. To retrofit faulty or missing components as recommended in the standard design and as per best practices.
4. To propose design (infrastructural) or process (functionality) changes to enhance performance by
 - a. introducing alternative or additional components and measures, and
 - b. adopting process change by modifying or retrofitting the existing systems.
5. To understand the practical challenges of implementing proposed improvements by piloting demonstrations in selected sites.
6. To analyse the feasibility of replication of interventions at the state level.

1.5 Methodology

The methodology adopted for this study builds on the principles of the Citywide Inclusive Sanitation (CWIS) approach and aligns with national and state sanitation guidelines, including IS 2470, CPHEEO manuals, and recommendations from the TNUSSP Baseline Assessment. CWIS, in consultation with the Tiruchirappalli City Corporation (TCC), developed a structured five-step framework to ensure that containment improvements are evidence-based, context-specific, and operationally feasible. The steps were derived from a review of earlier OSS assessments in Tamil Nadu, an understanding of existing urban sanitation service chains, and lessons from similar urban sanitation interventions across India. This framework also ensures that the study captures both technical and institutional dimensions of OSS improvement ranging from field-level assessment to solution design and validation.

The methodology followed in the study is depicted in Figure 1.1.



1.6 Assessment of Existing Containment Structures

To understand the condition and performance of existing OSS in Tiruchirappalli, a structured assessment was undertaken comprising both secondary and primary data collection. As a starting point, a literature review was conducted to examine existing scholarly work, technical guidelines, and sectoral studies relevant to OSS design, performance, and compliance. Key documents reviewed included the IS 2470 standards, the TNUSSP Baseline Assessment (2016), CPHEEO guidelines, and published studies on containment systems and faecal sludge management in Indian cities. The review revealed that while several state-level assessments highlight widespread design and performance challenges in OSS, there is limited city-specific evidence for Tiruchirappalli, particularly on typologies, construction practices, and compliance gaps. This study therefore contributes by generating primary, field-based evidence to fill this gap.

In parallel, the team undertook an analysis of existing practices related to OSS construction, maintenance, and desludging within the city. This included consultations with TCC engineers, masons, desludging operators, and informal sector workers to understand commonly used containment designs, materials, construction methods, maintenance behaviour, and disposal practices. These insights helped identify the diversity of OSS typologies and recurring issues across different neighbourhoods. This analysis was conducted across selected locations—not city-wide—but covered a representative mix of households, bulk waste generators, and areas with known containment-related challenges.

Based on insights from the literature review and initial consultations, the following primary data collection steps were undertaken:

1. Identifying and documenting typologies of containment and disposal systems through field observations.
2. Developing structured questionnaires for households, masons/contractors, and desludging operators (DSOs), included in Annexure 4.
3. Selecting sample sites covering different containment typologies, with a minimum of five OSS per typology, including both households and bulk generators.
4. Conducting field visits to each selected site to document design, sizing, construction, disposal arrangements, access, and maintenance practices.
5. Collecting second-level data, where required, such as cross-verification with TCC desludging records, discussions with ward engineers, and photographic documentation.
6. Analysing the consolidated dataset to identify gaps in design, construction, O&M, and compliance with IS 2470 standards.

This systematic approach ensured that the assessment was grounded in both a review of existing knowledge and detailed field-based evidence, thereby providing a reliable foundation for identifying containment improvement needs and selecting suitable demonstration sites.

1.7 Existing Containment Systems

The assessment identified that users were dependent on five types of OSS, and the study focuses on improvement measures for the typologies listed below.

- a) Septic tank connected to soak pit: A watertight containment connected with a soak pit (a porous chamber that allows wastewater to soak into the ground).

- b) Septic tank connected to stormwater drain: A watertight containment connected to an open drain.
- c) Holding tank: A watertight containment with no outlet.
- d) Single pit: An unsealed dug pit with openings at the bottom or walls or both.
- e) Twin pit: Two pits leaching out liquid content and retaining the solids.

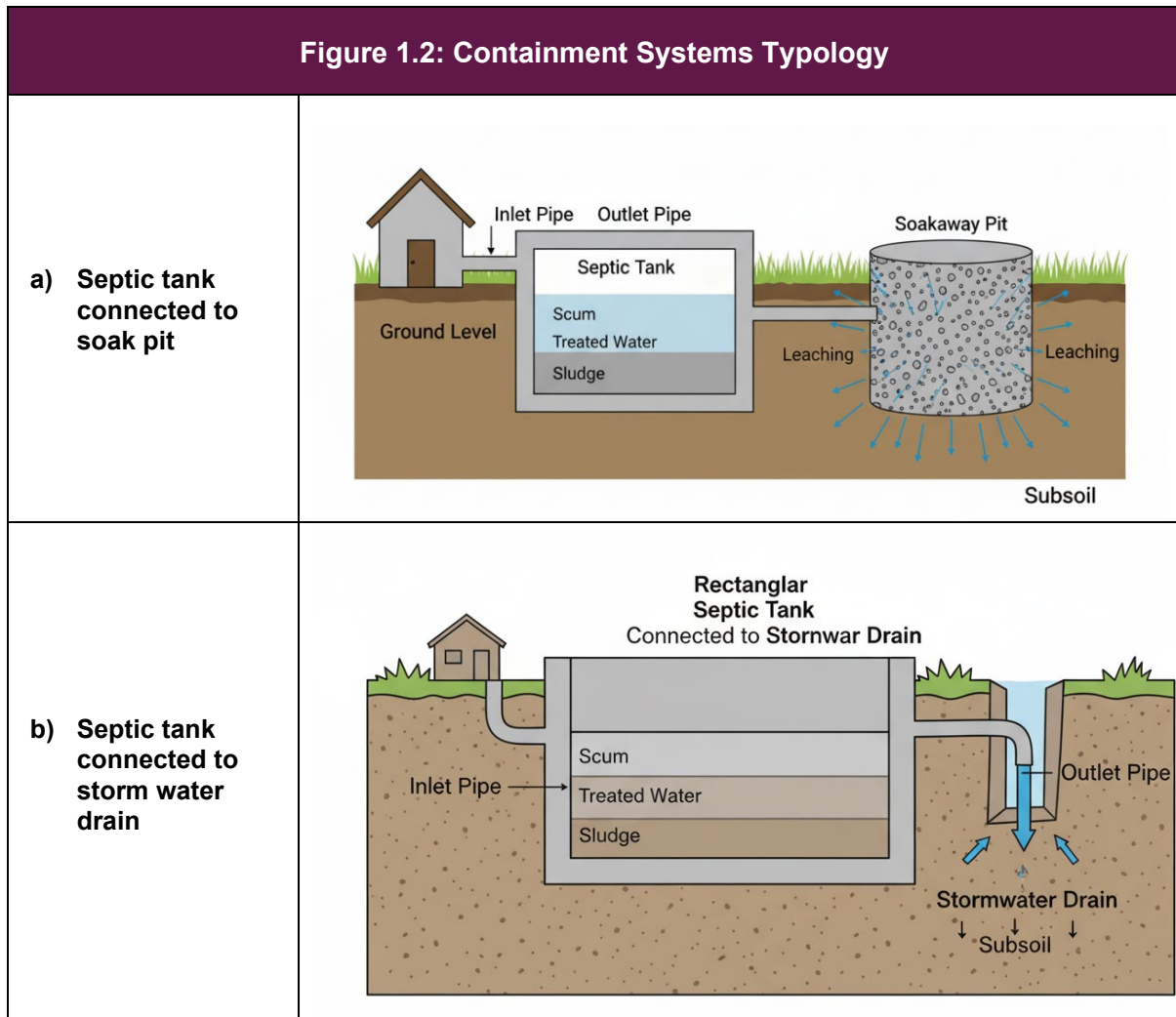
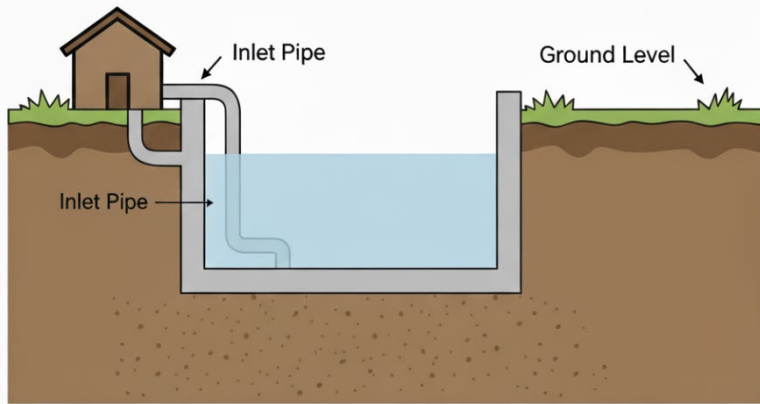
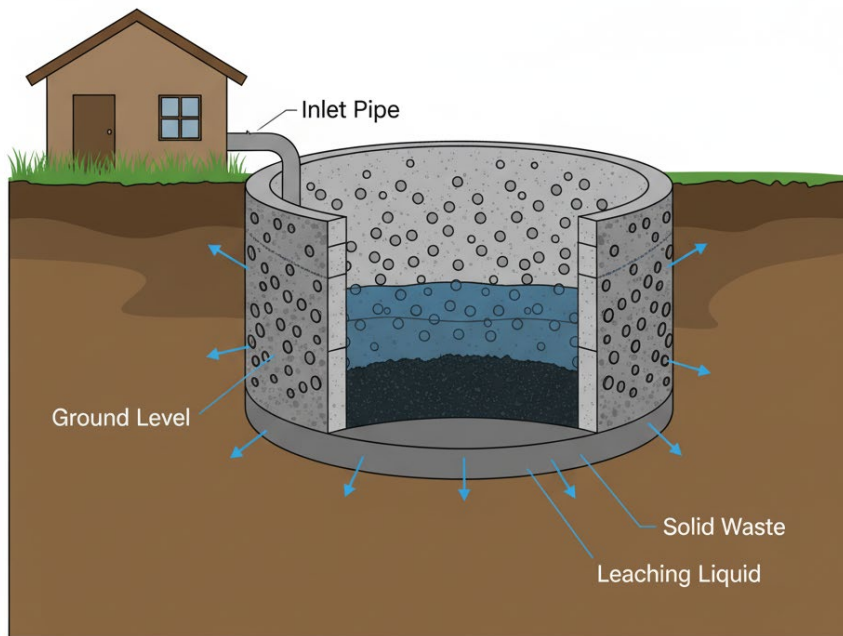


Figure 1.2: Containment Systems Typology

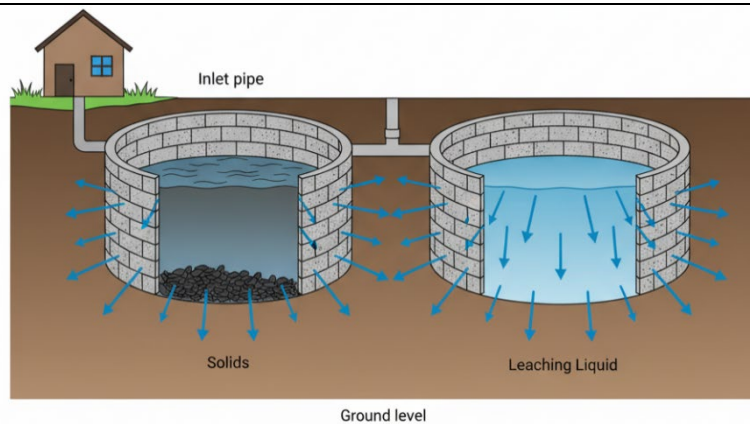
c) Holding tank: A watertight containment with no outlet.



d) Single pit: An unsealed dug pit with openings at the bottom or walls or both.



e) Twin pit: Two pits leaching out liquid content and retaining the solids.



Source: CWIS, 2020

1.8 Assessment findings

According to the assessment, existing containments were non-compliant under the Indian Standard (IS) 2470 design standards and did not meet the O&M parameters. A summary of field observations and recommendations is provided in **Annexure 1**. Besides infrastructure, other causes for non-compliance of standards were,

1. **Lack of space:** Most designs were selected based on the available space within the housing premises. This has led to the construction of under-designed or over-designed containment systems. The former was when households constructed septic tanks in the small space available after completion of main building due to least priority, and the latter was when households constructed larger units to decrease the frequency of de-sludging.
2. **Lack of knowledge:** Engineers and masons were unaware of standard septic tank design and construction, leading to the use of pits lined with concrete rings as septic tanks.
3. **Budget Constraints:** A key factor influencing the choice of technology is the budget of customers. This limits the choice of containment unit as builders must remain mindful of market pressure to offer cost-effective solutions, while also meeting the requirements of IS code.
4. **Non-enforcement of regulation:** Lack of mechanisms to monitor adherence of OSS construction to the Combined Development and Building Rules (Municipal Administration and Water Supply Department, 2019) prevents the enforcement of regulations.
5. **Unwillingness for frequent de-sludging:** Households tended to avoid de-sludging due to the inconvenience and costs involved.

1.9 Assessment of existing structure

Before undertaking containment improvement, a series of pre-implementation activities were carried out to confirm that the selected sites were technically suitable and operationally feasible for demonstration. These activities included multiple rounds of field visits, detailed assessment of the existing containment structures, and consultations with a range of stakeholders. In addition to discussions with households, interactions were held with desludging operators (DSOs) to understand access constraints, desludging frequency, and challenges faced during routine operations. Consultations with masons and local builders provided insights into common construction practices, material choices, and the reasons behind deviations from standard designs. Meetings with TCC engineers and ULB officers helped validate site feasibility, understand regulatory requirements, and identify any operational limitations related to road access, utilities, or future development plans.

Each site was evaluated based on containment type, space availability, desludging patterns, disposal arrangements, and stakeholder readiness. The combined insights from households, DSOs, masons, and ULB officers informed the selection of appropriate improvement measures and technologies under Categories 1 and 2. Necessary permissions were obtained from TCC and the respective user communities before commencing physical improvement works.

Containment Improvement Interventions

2.1 Recommended Improvements 13

2.2 Demonstrations 13



2. Containment Improvement Interventions

A review of the assessed containment systems shows that the infrastructural issues observed across the city are closely linked to the five underlying factors identified earlier. In dense settlements, limited space often results in undersized tanks, shallow pits, or single-chamber structures constructed within building plinths, all of which compromise required retention time and treatment. Limited awareness of standards such as IS 2470 further leads to systems lacking baffles, inlet/outlet tees, ventilation, or watertight surfaces, causing short-circuiting of flow and overflow into drains or surrounding soil. Cost constraints also influence construction choices, prompting households to opt for thin walls, poor-quality mortar, or unlined pits, resulting in structurally weak systems that leak, break, or fill rapidly.

These problems are compounded by heavy reliance on informal or untrained masons who construct containment systems based on local practices, leading to irregular sizing, incorrect invert levels, and absence of critical elements. Additionally, where desludging vehicle access is limited, households often create makeshift containment arrangements, including illegal outlets to stormwater drains, inaccessible tank placements, or soak pits located too close to foundations or water sources. Together, these conditions illustrate how spatial, socio-economic, and technical constraints translate into the infrastructure deficiencies summarised here and further detailed in the Annexure 1.

2.1 Recommended Improvements

The recommended improvement measures for OSS have been grouped into two categories based on the extent of modification required:

- **Category 1** are measures involving minimal changes to the existing containment structure. These aim to make the system compliant with IS 2470 standards through actions such as repairing leaks, improving access covers, and ensuring proper disposal arrangements like soak pits.
- **Category 2** are measures involving design or process enhancements to improve performance and safety. These include retrofitting existing systems, introducing new treatment technologies, or integrating alternative containment models to enhance efficiency, safety, and longevity.

A variety of containment improvement technologies were considered under these two categories. The key technologies included:

- Bio-digester systems (Defence Research and Development Organisation (DRDO) model and its variants)
- Readymade or prefabricated septic tanks
- Earthworm-based biofiltration systems (vermi-filtration units)
- Mechanical or electro-mechanical treatment systems
- Physical improvement measures such as internal partitioning, lining, baffle wall addition, and improved soak pits.

2.2 Demonstrations

To understand the practical challenges and field performance of the proposed improvement measures under both categories, pilot demonstrations were carried out in 13 OSS identified by the TCC.

These demonstrations improved the most common OSS arrangements in the city through the following methods:

- a. Septic tanks connected to soak pits – improved through standardised design, baffle walls, and soak pit reconstruction.
- b. Septic tanks connected to stormwater drains – retrofitted with proper disposal arrangements and gas control measures.
- c. Holding tanks – fitted with treatment and gas evacuation mechanisms to reduce desludging frequency and improve safety.
- d. Single pits – upgraded with improved lining, venting, or conversion to twin-pit systems for safe operation.

Each site adopted a suitable technology based on its existing condition, space and operational challenges, contributing practical insights into scalable models.

2.2.1 Discussion with households

The team explained the infrastructure and non-compliance issues in the existing containment units of the households, and highlighted the importance of constructing a new unit for better sanitation. They also emphasised the cost-effectiveness of the interventions and dangers of direct discharge of effluent into the drain which reaches a waterbody in the vicinity. Fifteen household were approached for this initiative and received their consensus.

For implementing new containment units, every household provided their consent through a form which permitted any maintenance activity to be carried out as needed. The households were further informed that in case of failure of the intervention, previous OSS will be reinstated and handed over.

2.2.2 Monitoring frequency

The OSS effluent was monitored before and after implementation to determine the effectiveness of improvement interventions. The monitoring period varied between two months to two years, depending on type and performance of the containment model. For example, the DRDO model requires less frequent monitoring when compared to the IS 2470 model.

2.2.3 Laboratory details

The sampling protocol provided in **Annexure 2** was followed during the monitoring period. The effluent was analysed for wastewater and microbial parameters listed in Table 2.1.

Table 2.1: Effluent quality parameters			
Characteristic	Parameter	Indicator of	
Wastewater	Biological Oxygen Demand (BOD)	Strength of pollution	
	Chemical Oxygen Demand (COD)		
	Total Solids (TS)	Total Suspended Solids (TSS)	Organic and inorganic content
		Total Dissolved Solids (TDS)	
		Total Volatile Solids (TVS)	
	Total Nitrogen (TN)	Pollution due to excess nutrients	
	Total Phosphorus (TP)		
	Potassium		
Chlorides	Efficiency of the disinfection system		
Microbial	Escherichia coli (E. coli)	Strength of disease-causing pathogens	

Source: TNPCB, 2019

Table 2.2 shows the frequency of sampling with respect to effluent parameters.

Table 2.2: Sampling frequency of effluent	
Parameters	Frequency of testing
BOD, COD and TSS	Once in 15 days
Nutrient Analysis (Nitrogen, Phosphorus, Potassium)	Once in 3 months
Sludge depth	Once in 6 months

Source: CWIS, 2022

The findings of lab tests of these samples are provided under the respective demonstrations in the following sections.

Bulk Generator-level Demonstrations

3.1 Improved septic tank 19

3.2 Earthworm-based Bioreactor with Digester 26



3. Bulk Generator-level Demonstrations

Bulk generators such as community toilets and large shared sanitation facilities present critical containment challenges due to high wastewater loading rates, short retention times, and inadequate or absent disposal arrangements. These factors often lead to rapid tank filling, frequent overflows, structural deterioration, and increased gas generation, resulting in operational inefficiencies and heightened occupational safety risks. The demonstrations at these sites aimed to enhance containment performance, reduce de-sludging frequency, minimise operational costs, and ensure safer disposal and maintenance practices.

The specific objectives were to:

- Improve treatment capacity and reduce the shutdown of CT.
- Reduce frequency and cost of de-sludging through structural and process improvements.
- Demonstrate technologies suitable for scale-up in other high-load community toilet settings.

The following technologies were demonstrated for containment improvements in bulk generators:

1. Improved septic tank
2. Earthworm-based bioreactor with digester

3.1 Improved septic tank

The improved septic tank is a concept of improving existing septic tanks by adding baffle walls and anaerobic filters based on site-specific requirements. Improving existing tanks will reduce the frequency of de-sludging, improve treatment efficiency, and reduce contamination around the area.

3.1.1 Site selection

For demonstration, a CT located at RMS Colony, Anna Nagar (Edamalapattiputhur), with about 90–110 users, was selected based on a sanitation needs assessment conducted in 2020.

3.1.2 Needs Assessment

By tracking the de-sludging vehicle of TCC, it was observed that the selected CT had high frequency of de-sludging, since it did not have proper disposal arrangements. This also led to increasing complaints from users on delay in de-sludging and the non-functioning of CT until de-sludging was complete. Hence, a community-level needs assessment was carried out in 2020 to understand the decreased usage of the CT. The assessment showed that the toilet needed major improvement in its containment system, and provisions for inclusive sanitation.

3.1.2.1 Observations

Initial assessment of the containment showed leakage, frequent de-sludging, and huge sludge accumulation.

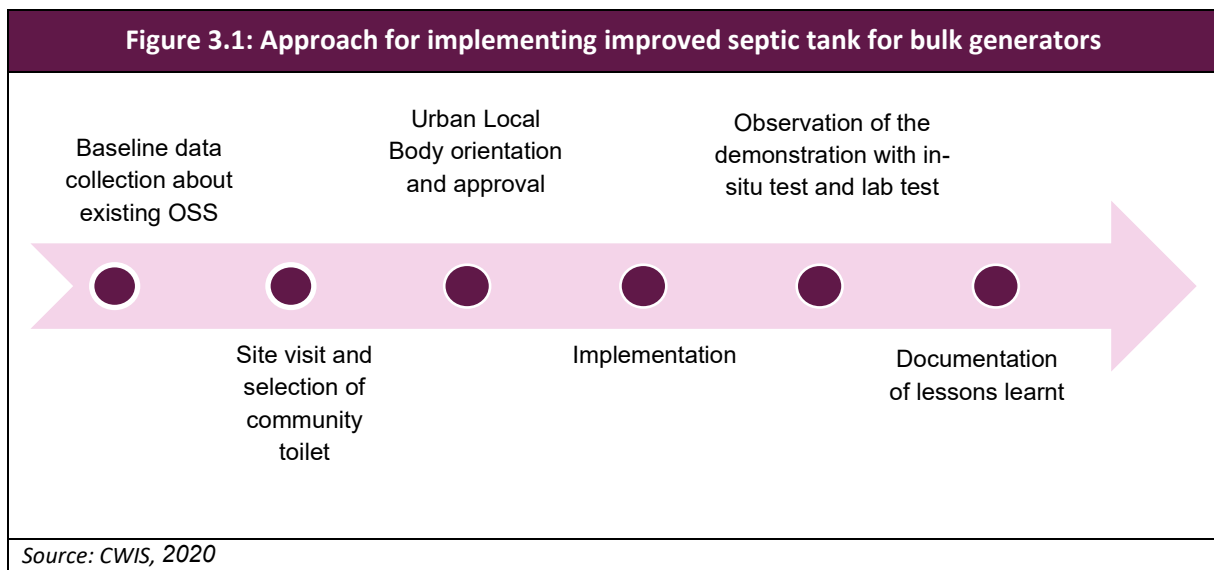
Table 3.1: Status of existing containment at RMS Colony

Description	RMS colony community toilet	Status
Containment type	Septic tank	-
Water tightness	Leaking	To be rectified
Disposal	Not available	Safe disposal arrangements required
Baffle wall openings	<ul style="list-style-type: none">• 2 baffle walls at equal distances• Opening at bottom	Need to be upgraded as per IS
Inlet and outlet	<ul style="list-style-type: none">• No T-pipe at inlet• No outlet	T-pipe provision required
Access openings	Damaged access opens (manholes)	Need to provide access holes at cover slabs
Vent pipe	Broken vent pipe	Damaged
Condition of wall, floor, and cover slab	<ul style="list-style-type: none">• Leaking walls• Hard slit accumulated on floor• Undamaged cover slab except access opens	

Source: CWIS, 2022

It was proposed to modify the existing septic tank by installing a new primary settling tank (settler). The proposed improvement would have the capacity to treat 7 kilo litres per day (KLD) and dispose of the effluent by land or soil dispersion methods.

3.1.3 Implementation approach



3.1.4 Sampling

The sampling frequency has been derived based on the implementation plan which was once a month. The samples were analysed for BOD, COD, and TSS.

3.1.5 Implementation

Two approaches were adopted in improving the septic tank:

- Ensuring the continuous functioning of the toilet and treatment system, and
- Improving existing containment as per Central Public Health and Environmental Engineering Organisation's design recommendations.

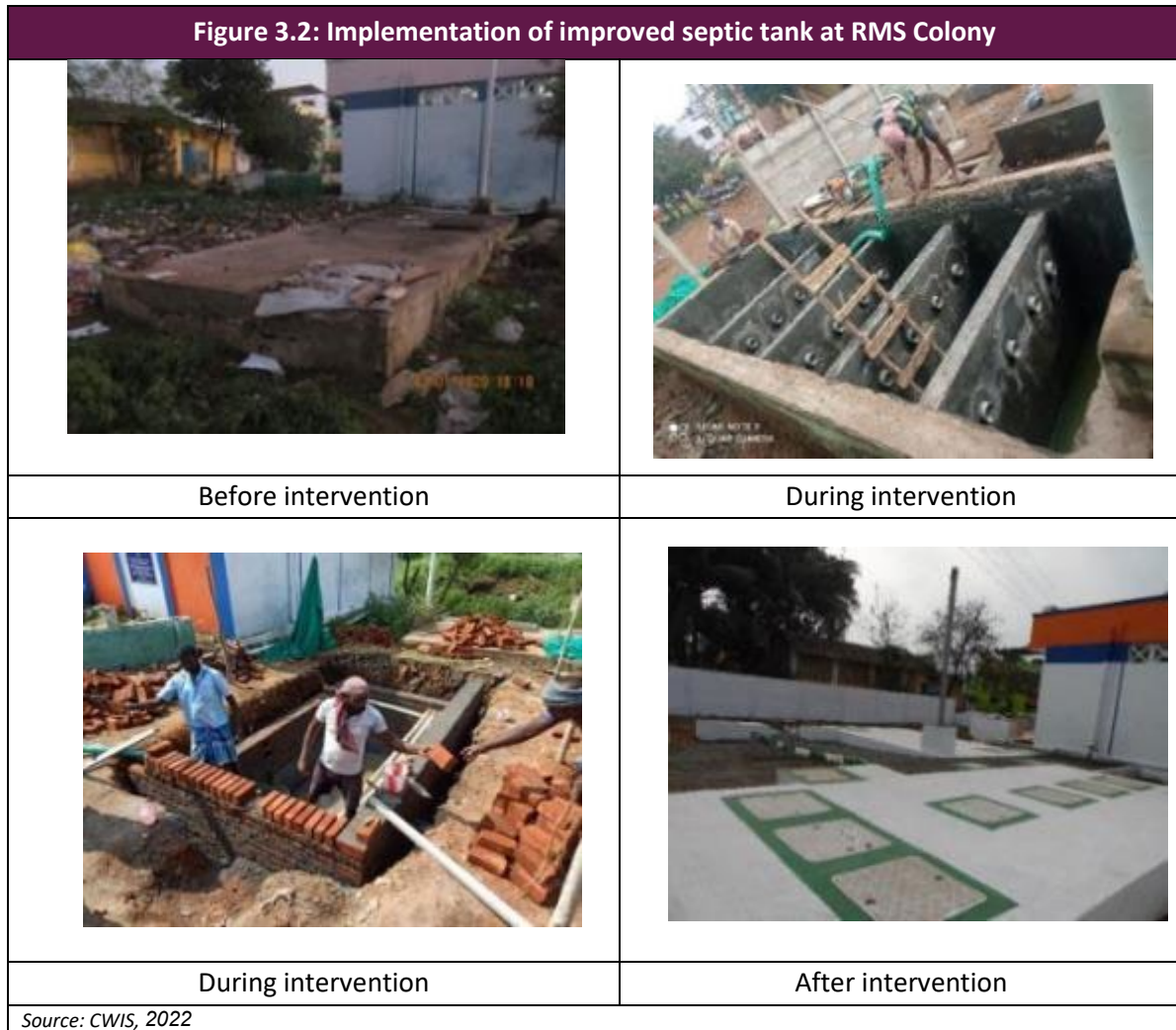
While the site visit, transect walk and designing of systems were completed during January 2020, work at site was initiated in December 2020 due to COVID-19 protocols.

A primary settler with dispersion pit was constructed initially to run the toilet without disruptions. Wastewater was diverted to the primary settler and activities on secondary treatment unit was initiated. The existing septic tank was improved by constructing an Anaerobic Baffled Reactor (ABR) and Anaerobic Filter Reactor (AF).

The ABR consists of a series of baffles that compartmentalise the reactor tank into three chambers. Wastewater is forced to flow upward through the chambers, where the pollutants get biologically broken down by anaerobic bacteria in an active sludge layer at the bottom of each chamber. The organic content in the wastewater gets progressively degraded in the subsequent chambers, thereby reducing BOD by 65 to 90 per cent.

AF are secondary treatment units where remaining pollutants from ABR effluent are further treated by anaerobic degradation. It is a fixed bed biological reactor, where the organic matter breakdown occurs through extensive contact between wastewater and microbial biomass developed on the filter media. The treatment of wastewater by AF ensures a reduction in BOD by 65 to 85 per cent.

Since the septic tank had leakages, it was continuously dewatered until masonry work was completed. A filter bed (perforated RCC slab) was provided to place the filter media, and two baffle walls were constructed in addition to existing baffle walls. Elongated T-pipes were placed at the inlet of each chamber to prevent scum from passing between chambers, enhance the digestion process, and reduce the effluent flow velocity. The implementation was completed during January 2021, and the system has been running since February 2021.

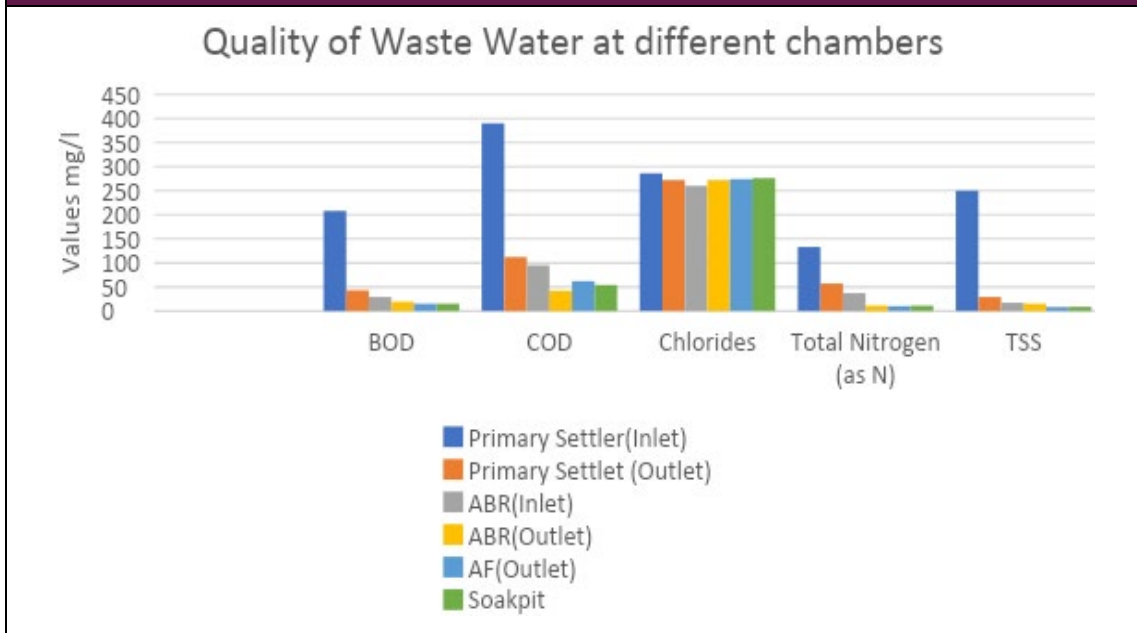


3.1.6 Performance

The quality of the treated water in the containment was monitored between February 2021 and February 2023. The results showed that biological treatment in the improved septic tank was effective. The high concentration of COD and BOD in the primary digester was significantly reduced after treatment in the ABF and AF. Till 2024

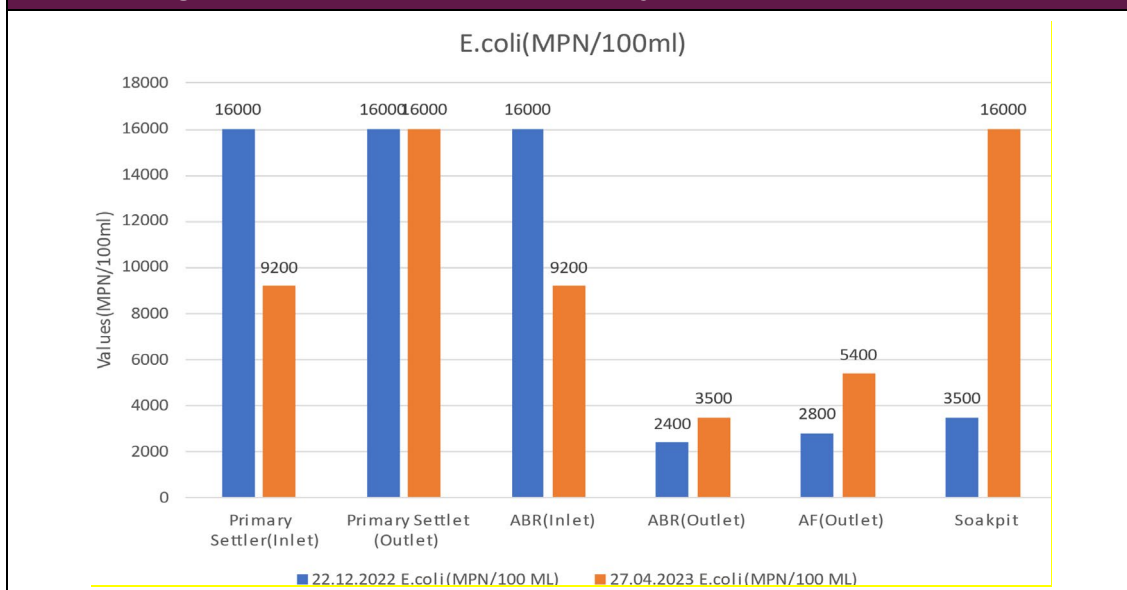
, the system has treated and safely disposed of 1 million litres of wastewater. Figure 4.3 depicts the unit-wise performance of the system.

Figure 3.3: Performance efficiency of improved septic tank



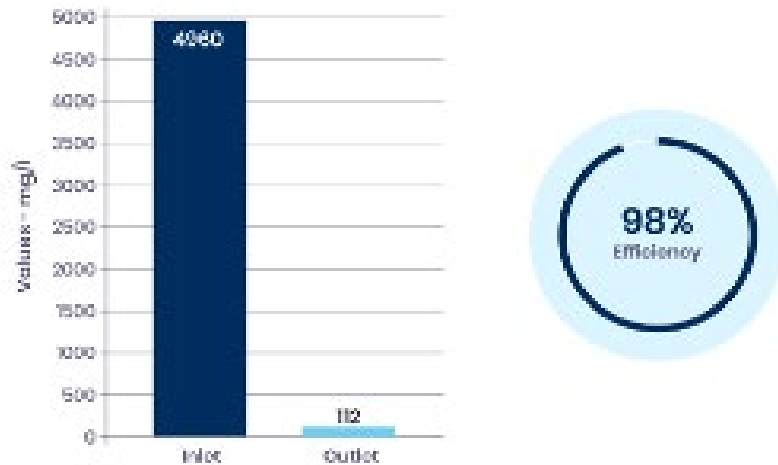
Source: CWIS, 2023

Figure 3.4: E. coli removal efficiency of improved septic tank



Source: CWIS, 2023

Figure 3.5: COD removal efficiency of improved septic tank



Source: CWIS, 2023

Figure 3.6: BOD removal efficiency of improved septic tank



Source: CWIS, 2023

3.1.7 CapEx and OpEx

The capital cost was in the range of INR 4,49,000 – 6,49,000 and the OpEx is INR 15,000. Estimated LCC is between INR 480,000 and INR 838,000 for a span of 15 years. For detailed estimates please refer to **Annexure 6**.

3.1.8 Challenges and Outcomes

Implementing improvements to the existing containment and superstructure was a complicated task. The challenges faced by the team during execution are documented below.

- a. Higher risks in renovating an old water-retaining structure (septic tank) as the chances of the structure collapsing were high.
- b. Difficulty in arresting leakage in the brick-walled septic tank compared to concrete walls.
- c. Difficulty in maintaining the existing hydraulic levels for the disposal arrangement while retrofitting an old septic tank.
- d. Difficulty in de-sludging hardened sludge deposited at the bottom of the containment structure for nearly 10 years.
- e. Ensuring safety of workers while renovating the existing containment structure and while working in a septic tank.
- f. Limited time (non-operative hours of CT, i.e., between 12 PM and 4 PM) for carrying out implementation as improving infrastructure simultaneously during the operation of the CT was difficult.
- g. Unavailability of special water closet, toilet pan and commode for differently-abled people in the local market.
- h. Difficulty in increasing toilet usage among community dwellers due to the reluctance in adopting the pay-and-use model.
- i. Difficulty in continuing the operation of CT through members of self-help groups.

3.1.9 Outcomes

Even though there are many mechanised sewage treatment plants available in the market, this simple gravity-based treatment system is most suitable for the CT containment improvement, if the adequate area is available. Further action items to scale-up the containment improvements are listed below.

1. TCC to adapt this model for other wards in the city.
2. Better service to the community.
3. Reduction of de-sludging frequency and cost as the settled sludge would be removed once in three years.
4. Low maintenance of the treatment system, including the primary settler.
5. No overflow from the dispersion pit due to proper functioning of disposal arrangement without blockages.

3.1.10 User experience

Users compared their experiences in using the CT before and after containment improvement and their views are listed below,

1. Easier access to the toilet
2. No leakage from the containment
3. No bad odour
4. Improved aesthetics
5. Increased usage of CT by differently-abled people after the installation of ramp facility
6. Decreased open defecation by children due to separate children's toilet facilities

3.2 Earthworm-based Bioreactor with Digester

EBR is a sustainable containment improvement method in which septage is treated through aerobic decomposition of epigeic earthworms. The continuous movement of earthworms loosens the surface layer thereby creating aerobic conditions for the treatment of wastewater.

3.2.1 Site selection

The EBR system requires a suitable site, ideally near a community toilet septic tank, with sufficient space (2 to 3 sq. m) to accommodate the reactor. Essential site requirements include access to an electrical supply to power the transfer pump, ensuring efficient wastewater flow through the reactor. Additionally, the area must be adequately covered to protect the EBR and earthworms from rodents and other pests, preventing disturbance and ensuring uninterrupted biological activity.

The site for implementing EBR selected was the containment of the Thulasinganagar CT, constructed on the banks of the Koraiyar River channel. It serves a community of 60 to 70 users per day, and its water usage is 1 KLD per day.

3.2.2 Observations

The toilet, located on the riverbed prone to flooding, was overflowing and the untreated waste was disposed of into the environment. During site assessment, it was observed that the septic tank structure was not completely damaged. However, there were no proper provisions for effluent disposal in the containment. The flooding of the containment hindered access to users every monsoon from October to December, who consequently resorted to open defecation. The containment was a septic tank having a size of 10 m x 3 m x 2 m.

Figure 3.7: Status of containment before intervention in Thulasinganagar



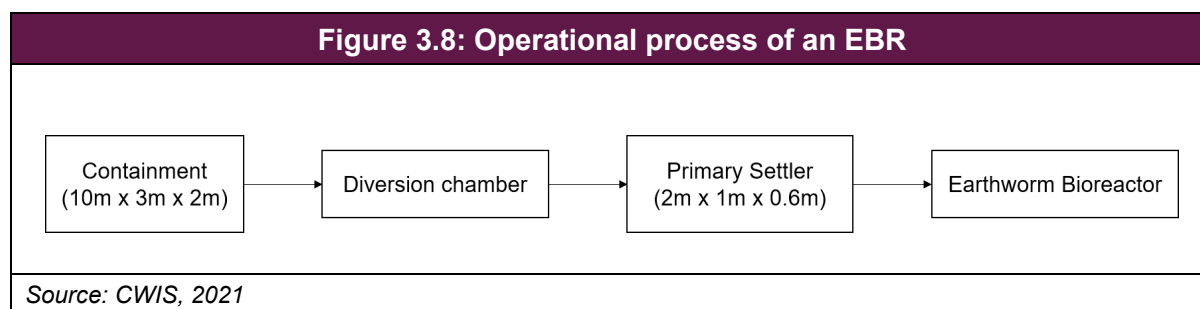
Source: CWIS, 2020

3.2.3 EBR system

Major improvements were required to,

1. Strengthen the existing containment and prevent flooding.
2. Provide a low-cost and affordable technology to treat the secondary effluent from the containment.

To improve the situation, a watertight containment with an elevated secondary effluent treatment system using EBR technology was constructed.



3.2.4 Sampling

BOD, COD, and TSS were the major parameters analysed, and all the three labs were utilised for the analysis.

3.2.5 Implementation

The existing system was designed for 2 KLD, but the access openings and vent pipe were damaged with silt accumulation at the bottom. Prior to the installation of EBR, the containment was de-sludged, made watertight by repairing the damaged slabs and side walls, was provided a vent pipe, and blockage was removed in the effluent pipe.

The EBR had primary and secondary treatment units wherein the primary had coarse screen to remove large solids, and the secondary treatment consisted of the bioreactor, which used cocopeat as packing material.

3.2.5.1 Initial setup of the bioreactor

A primary settler was constructed to receive the secondary effluent from the septic tank, from where it was pumped to the EBR system.

a) Primary settler and pump

A Sintex 1000-litre rectangular tank was used as the primary settler with the dimensions 2 m x 1 m x 0.6 m. A small (22 watts) pump was used for transferring settled water to EBR.

b) EBR setup

Refer to section 3.3.1 for the working principles of EBR.

The system consisted of the following components:

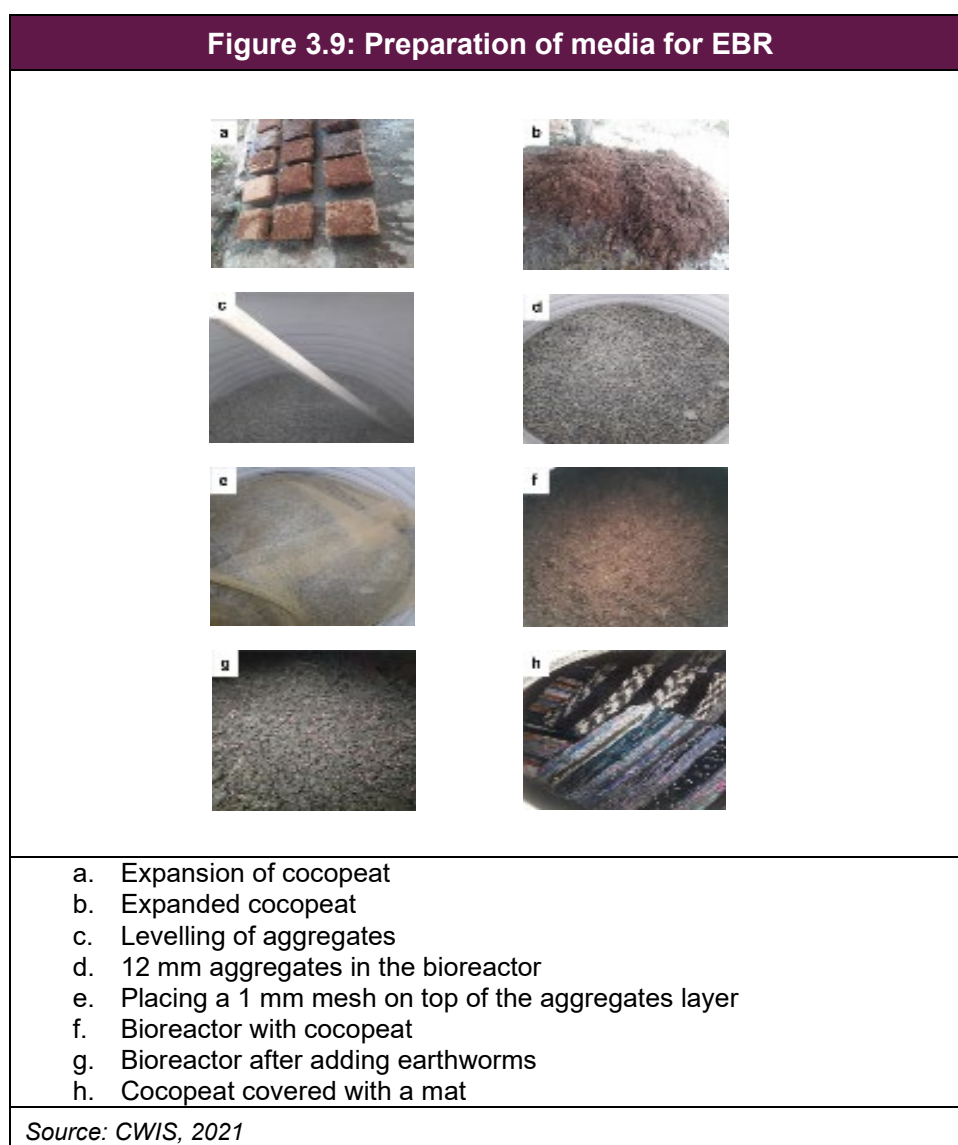
Container: 1000-litre High Density Polyethylene (HDPE) tank was used as the bioreactor.

Aggregates: A drainage layer consisting of 40 mm aggregates and 12 mm aggregates each for a depth of 10 cm was prepared. A 1-mm mesh plastic mesh was spread on the top of the 12 mm aggregate layer.

Active layer: Low EC cocopeat was expanded by the addition of water and constituted about 70 cm of the bioreactor. Fifteen units of 5-kg cocopeat blocks were used. Around 20-30 litres of water were added to enable the expansion and loosening of each cocopeat block.

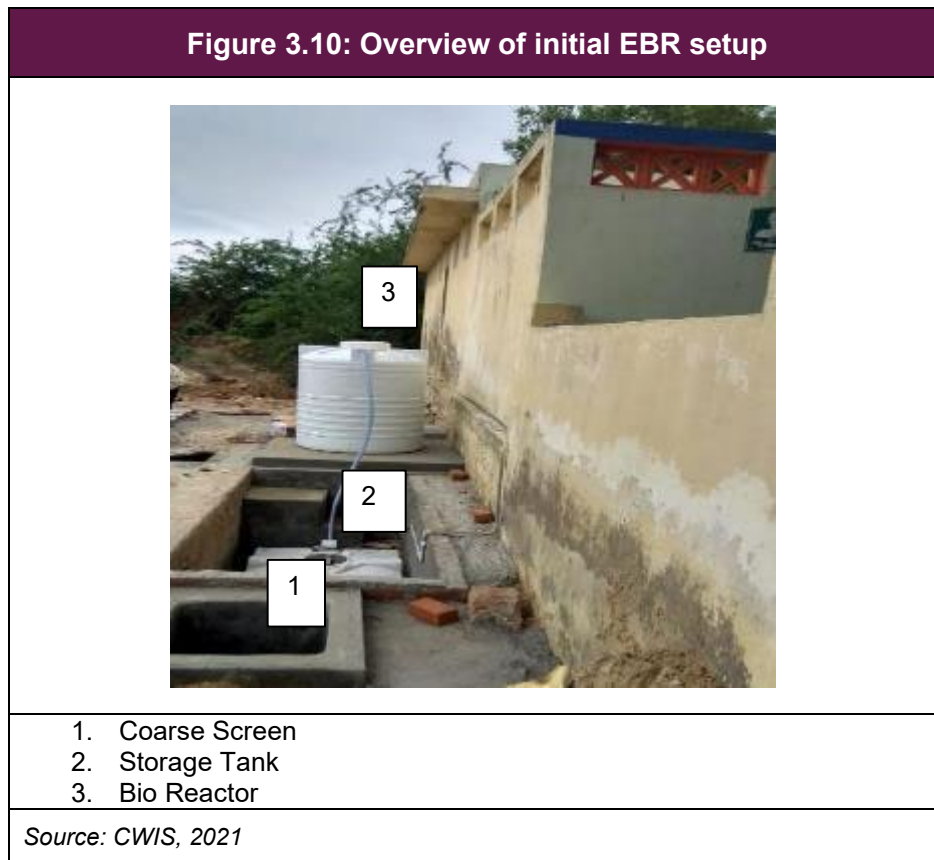
Earthworms: Epigeic earthworm mixture (*Eudrilus eugeniae* and *Eisenia fetida*) of about 2 kg and vermicompost were added to enable the smooth transition of the earthworm habitat from vermicomposting unit to the bioreactor. The surface layer of the bioreactor was covered with floor mats to enhance the distribution of water before filtration.

The sequence of events involved in preparing EBR media is illustrated in Figure 3.9.



The HRT of the wastewater in the bioreactor was calculated by noting the time taken for the water to pass the bioreactor, and was found to be 30-45 seconds and 2-3 minutes before and after placing the

distribution arrangement, respectively. The components of the initial setup of the system are shown in Figure 3.10.



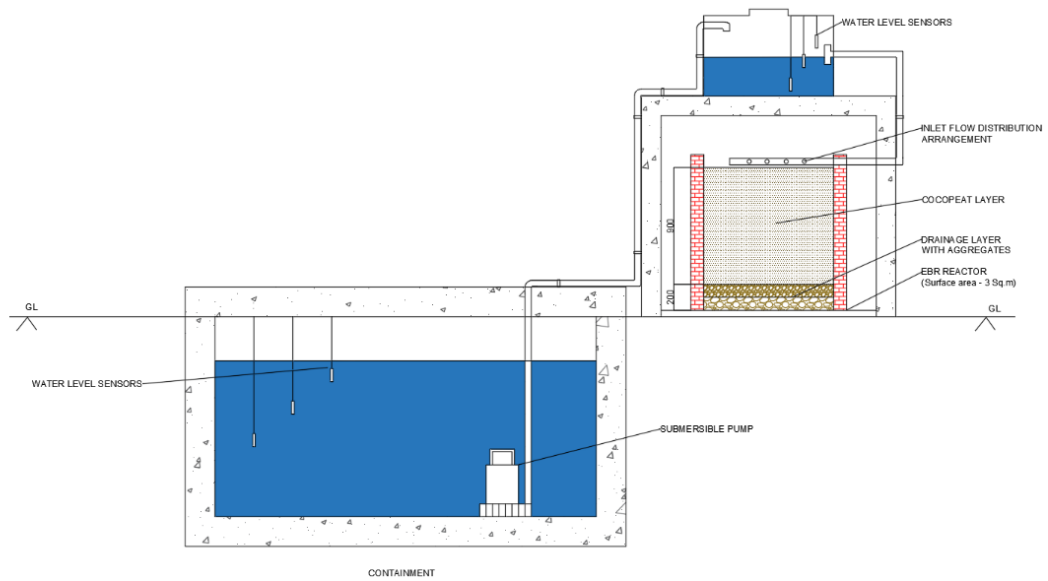
3.2.5.2 Sampling

The setup was only monitored for two months (October and November 2021) as the system was flooded during the monsoon. The average BOD, COD, TN, and TP removal efficiencies were found to be 52 per cent, 43 per cent, 44 per cent, and 26 per cent respectively.

3.2.5.3 Upgraded setup of the bioreactor

The containment improvement was further upgraded to 3 KLD capacity to address flooding-related challenges during monsoon, and the unit was constructed at an elevated level as described in the schematic diagram in Figure 3.11.

Figure 3.11: Schematic diagram of EBR in Thulasinganagar



Source: CWIS, 2020

The field implementation is shown in the Figure 3.12 below.

Figure 3.12: Current upgraded EBR at Thulasinganagar

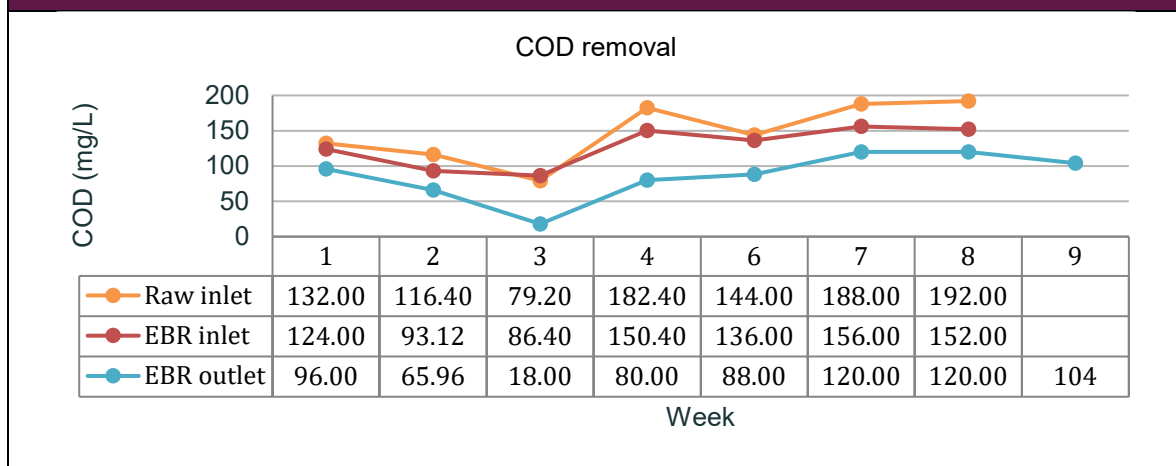


Source: CWIS, 2022

3.2.6 Performance

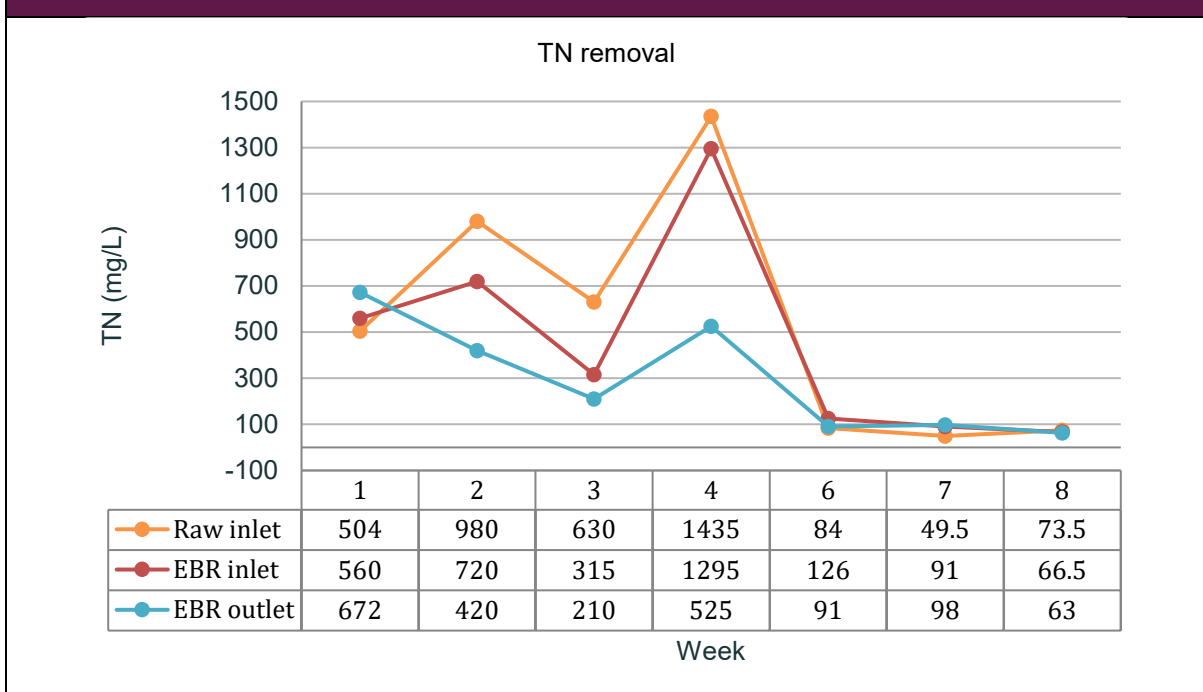
During the initial stage of monitoring, the removal efficiency of BOD, COD, and TSS was 54 per cent, 53 per cent, and 84 per cent, respectively. After three months, EBR performance improved to 84 per cent, 90 per cent, and 89 per cent, for BOD, COD, and TSS respectively. The average total nitrogen removal during the initial stage was 44 per cent, and after three months, the removal efficiency increased to 67.5 per cent.

Figure 3.13: COD removal efficiency of EBR at Thulasinganagar



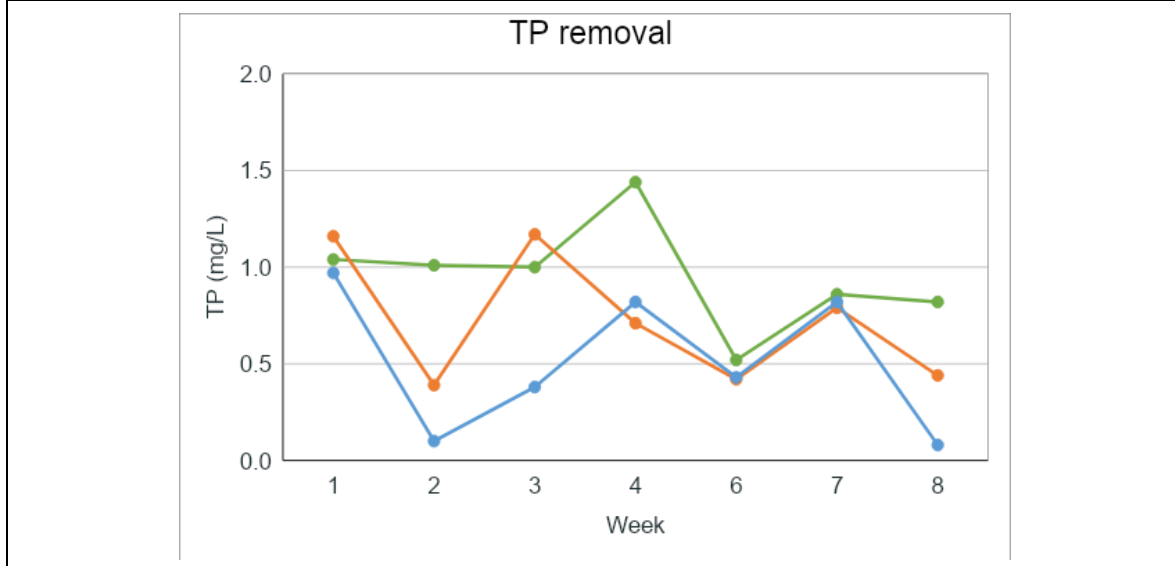
Source: CWIS, 2023

Figure 3.14: Total Nitrogen removal efficiency of EBR at Thulasinganagar



Source: CWIS, 2023

Figure 3.15: Total Phosphorus removal efficiency of EBR at Thulasinganagar



Source: CWIS, 2023

3.2.7 CapEx and OpEx

The capital cost for the initial model was INR 45,000 and for the upgraded system, the estimated CAPEX for the improvement (3 KLD system) is INR 1,42,000 while the estimated OPEX INR 9,000.

3.2.8 Challenges and outcomes

The challenges related to the containment improvement are listed below:

1. Difficult to retrofit septic tank in its existing conditions
2. Reduced treatment performance due to greater accumulation of grit inside the existing septic tank
3. Difficult to select earthworms suitable for the system
4. Challenging to monitor earthworms

The demonstration showed that improvement through EBR system was a viable solution in flood-prone areas, and could be adopted for improving the containment systems of CT in other flood-prone areas, the plans for which are in the conceptual stage. While the performance of the low-cost system was within the standard disposal limits, it needed periodic monitoring.

3.2.9 User experience

Based on the field trial and observations from the caretaker of the CT, the following feedback were obtained,

1. No major challenges faced on the operation perspective
2. Improvement of area around the septic tank after implementation
3. Operational even during floods

Household-level Demonstrations

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4.6 Effluent Treatment using Chlorine Tablet System	60



4. Household-level Demonstrations

4.1 Introduction

Household-level demonstrations were undertaken to test and validate containment improvement measures suitable for individual dwellings. These pilots focused on enhancing system performance, safety and compliance with design standards through practical, site-specific interventions.

The following options for household-level containment improvements have been demonstrated in the field,

1. Improvement as per IS 2470
2. Reinforced Cement Concrete (RCC) Prefabricated Circular Septic tanks
3. Earthworm-based Bioreactor (EBR)
4. Biodigester with DRDO patented bio-culture
5. Effluent treatment – Chlorine Tablet System

4.2 Improvement as per IS 2470

A septic tank is a key component of a decentralised wastewater treatment system, commonly used in areas without access to a centralised sewer system. The tank is designed to separate solids and liquids, with solids settling to the bottom and liquids flowing out through the outlet pipe into a drain field for further treatment.

4.2.1 IS 2470 Septic Tanks

IS 2470 outlines the technical requirements for the construction of septic tanks in India. Septic tanks must adhere to the standards to ensure that it is structurally sound, watertight, and capable of treating wastewater effectively, while minimising environmental impacts.

The design specifications recommended by IS 2470 are listed below.

- Dimensions:* The length to breadth ratio should be within the range of 2 to 4, as a lesser ratio will reduce the settling efficiency. The minimum width of the tank should be 750 millimetre (mm) and minimum water depth required is 1 metre (m). However, from practice, it is observed that higher depth (1.5 m – 2 m) yields better efficiencies. The recommended dimensions based on the number of users are depicted in Table 4.1.

Table 4.1: Septic tank sizes recommended by IS 2470				
No. of users	Length (m)	Breadth (m)	Liquid depth (m)	
			1 year	2 years
5	1.5	0.75	1	1.05
10	2	0.9	1	1.4
15	2	0.9	1.3	2
20	2.3	1.1	1.3	1.8

Source: IS 2470, 2022

- ii. *Retention time:* It is recommended that a Hydraulic Retention Time (HRT) of 24-48 hours is maintained. While Solids Retention Time (SRT) is not included in the code, based on general practice, it is proposed to be 24-36 months. A higher retention time can give better treatment efficiency; however, it may be difficult to de-sludge the thickened sludge.
- iii. *Proximity to surface water and ground water table:* A minimum distance of 18 m must be provided between soakaways and drinking water sources.
- iv. *Partition walls:* Provision of partition walls would ensure sedimentation of solids, and enhance the quality of effluent at the outlet.
 - Location of partition walls
While septic tanks should have a minimum of one partition (baffle) wall, providing more than one partition wall will help achieve better settling efficiency. Single partition wall must be provided at a distance two-third from the inlet of the tank, and for two walls, the first wall should be located at half the length from the inlet and the second at one-fourth length from the outlet.
 - Openings in partition walls
The number of openings required shall be derived with reference to the total width. The rectangular or circular openings in the partition wall should have a minimum diameter of 100 mm (ideally 150-200 mm), and should be 300 mm below the water level at a spacing of 300 mm.

4.2.2 Site selection

A household in Srirangam was selected based on the age of the containment system, which also had heavy spillage around it. Underground drainage (UGD) connection was not possible since the septic tank outlet was more than 30 m from the UGD line. The red loamy soil in the area, known for its moderate permeability, influenced the type of containment improvement implemented, as it affects the percolation of wastewater and the efficiency of OSS.

4.2.3 Issues with the existing containment system

Baseline data was collected through field observations in January 2020. The containment unit for the eight member-household was a septic tank with soak pit disposal system. The observations showed that the containment did not meet the IS 2470 recommendations. The septic tank outlet was blocked and the soak pit was damaged. This caused an overflow of collected fecal matter and required frequent de-sludging. Table 4.2 lists the deviations of the containment from standard requirements.

Table 4.2: Status of the existing containment system at Srirangam				
S No.	Description	Observation	Recommended (IS 2470)	Status
1	Size	2.14 x 1.3 x 1.5 m	<ul style="list-style-type: none"> • Length - ≥ 1.5 m (diameter ≥ 1.35 m for circular tanks) • Width - ≥ 0.75 m • Effective depth - ≥ 1 m • Length to breadth ratio - 2 to 4 	Meets requirement

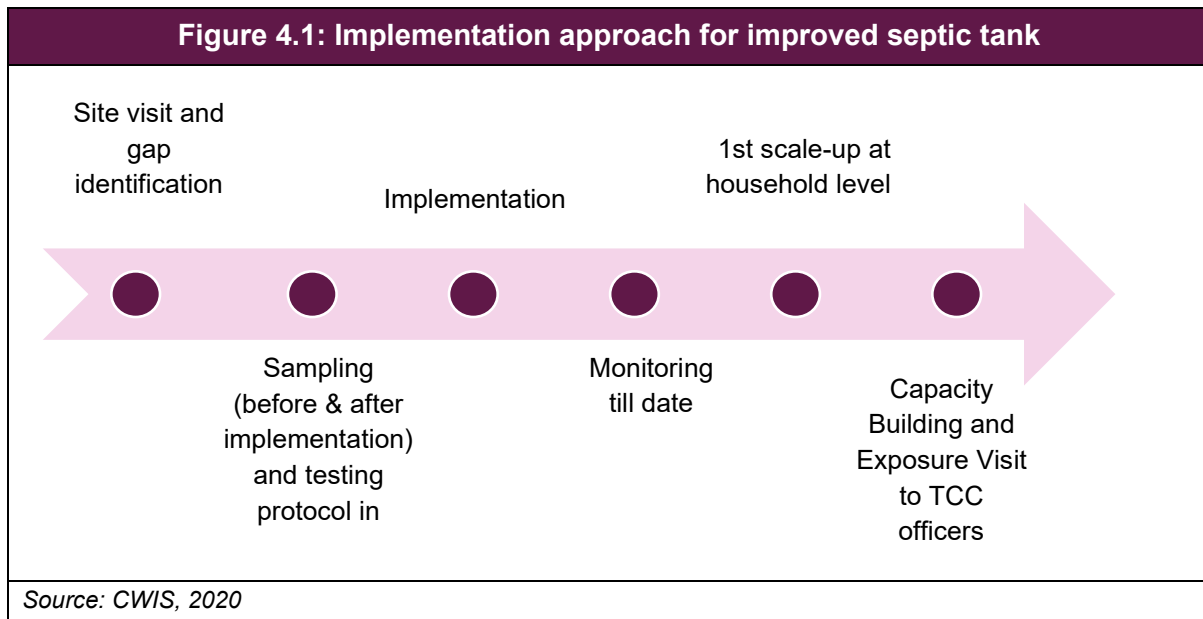
Table 4.2: Status of the existing containment system at Srirangam

S No.	Description	Observation	Recommended (IS 2470)	Status
2	Outlet	<ul style="list-style-type: none"> Connected to a soak pit Blocked soak pit Overflowing tank 	Outlet should be connected to a disposal system that shall be either a dispersion trench or soak pit (circular or rectangular). Outlet must be 0.05 m below the inlet and 'T' pipe provisions must be provided at inlet and outlet.	Absence of 'T' pipe provision
3	Baffle wall	Position: At 2/3rd length from the septic tank wall and at the depth of 1.5 m	Suitable openings rectangular or circular with minimum diameter of 100 mm and maximum of 150 mm shall be provided at approximately 300 mm below the Treated Water Level.	Baffle wall is provided at bottom of the wall
4	Plastering	Only inner walls were plastered	Plastering for a minimum thickness of 12 mm must be done on the inner and outer walls	Outer wall is not plastered
5	Construction Specification	<ul style="list-style-type: none"> Wall – Brick Floor – Concrete Top – Precast 	<ul style="list-style-type: none"> Walls should be constructed using bricks, stone, or concrete with plastering wherever required. Thickness of brick walls - >0.2 m Thickness of stone walls - 0.370 m Floor - M 15 concrete 	Absence of floor slope
6	Cover slab	Precast and damaged condition	The top slab must have a minimum thickness of 100 mm and be cast with adequate steel reinforcement. It should be provided on top of the septic tank and at least 0.3 to 0.45 m above ground level.	Damaged
7	Access	Not available	Each chamber should have a manhole with a minimum size of 0.455 x 0.61 m or 0.5 m diameter.	Absence of open access
8	Soak pit	Available, completely damaged	Cross section length of soak pit must be at least 0.9 m, and depth must be greater than or equal to 1 m	Damaged
9	Inlet position	0.3 m from the slab bottom	Rectangular or circular inlet of diameter between 100 to 150 mm and at 0.3 m below the top water level must be provided	Meets requirement
10	Vent pipe	Broken air vent	Vent pipe of diameter 0.05 m or more must be provided, and protected against mosquito breeding	Broken

Source: CWIS, 2020

4.2.4 Implementation timeline

The timeline for the implementation of containment improvement is depicted in Figure 4.1. Due to COVID-19 constraints, work on implementing interventions was initiated only in August 2020.



4.2.5 Implementation

Firstly, a single pit was constructed to divert the septic tank inflow during the implementation of the new unit. This was de-sludged, cleaned, and converted to a soak pit. The time taken for field implementation was eight days. In accordance with IS 2470, major refurbishments provided were baffle wall openings at the top, T pipes, sloped bottom, vent pipes, and raised side wall. The stages of containment improvement are provided in Figure 4.2.

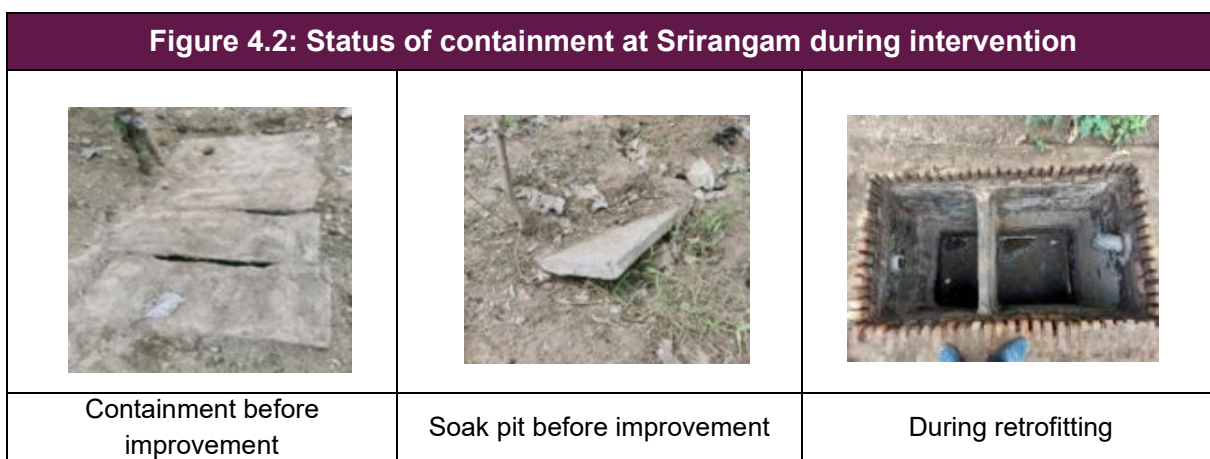


Figure 4.2: Status of containment at Srirangam during intervention



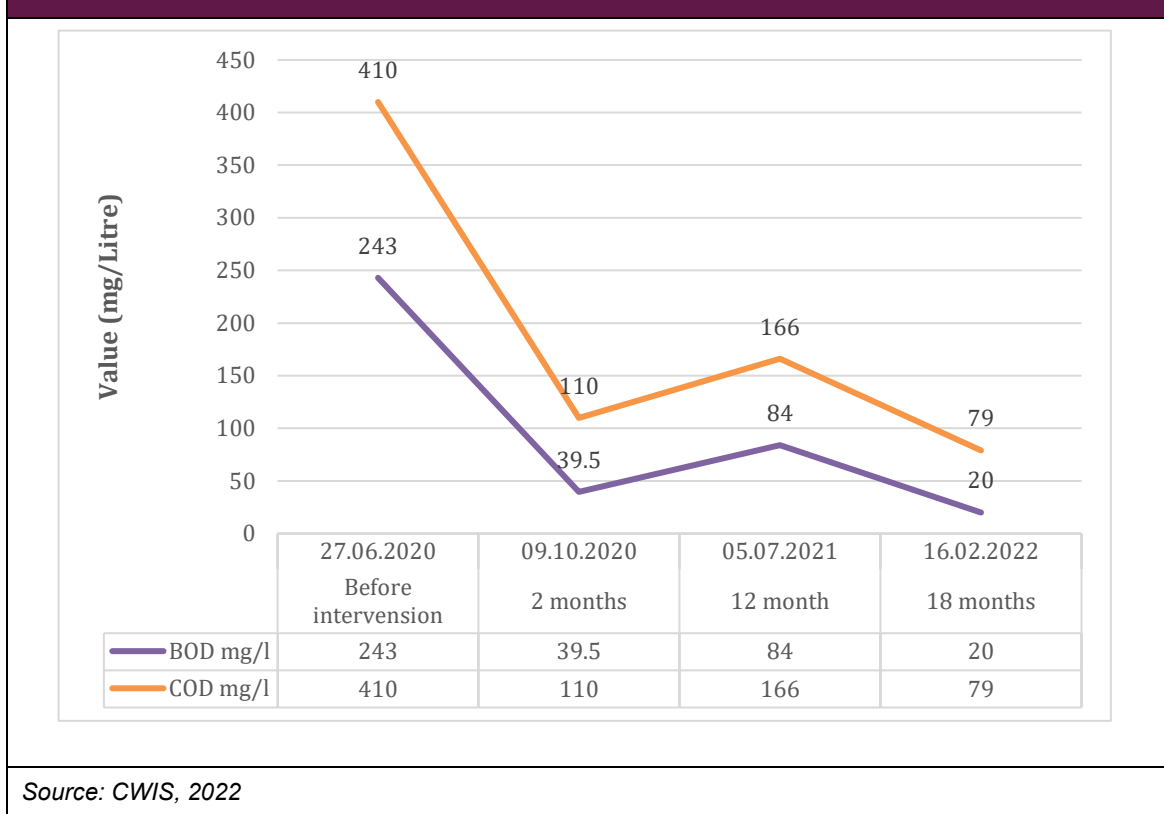
4.2.6 Sampling and analysis

Sampling and analysis were initiated during COVID-19, i.e., June 2020. Previously identified laboratories conducted the analysis of the samples.

4.2.7 Performance

After the modification, the treated effluent from the containment was tested and compared with that effluent quality before intervention. Figure 4.3 depicts the performance of efficiency of improved septic tank.

Figure 4.3: Performance efficiency of improved septic tank intervention



4.2.8 CapEx and OpEx

CapEx for the demonstration was in the range of INR 25,000 to 42,000 and estimated OpEx is INR 2500 once in 2 years. The retrofitting cost was borne under CWIS. The Life Cycle Cost (LCC) will be in the range of INR 68,000 to 85,000. Respective household is responsible for this LCC. For detailed breakup, refer **Annexure 6**.

4.2.9 Challenges and outcomes

The challenges of the demonstration were,

1. Absence of safety protocol for labourers working in containment improvement and later implemented.
2. Difficulty in assessing the current condition of the septic tank due to its age, structural deterioration and complete coverage.
3. Unavailability of trained labour.
4. Higher chances of collapse in old buildings due to external soil pressure.
5. Difficulty in determining household acceptance of new containment.

The following outcomes have been achieved by containment improvement:

1. Leakage from the existing system has been arrested.
2. De-sludging interval of the new containment system has increased, benefitting the household.
3. Effluent treatment quality has improved due to the modified partition wall arrangement.

4.2.10 User experience

Feedback obtained from the household before and a year after the implementation showed marked improvement in the sanitation condition of the household. They listed that,

1. There was no spillage around the septic tank.
2. There was no odour after the intervention.
3. Frequency of de-sludging reduced from once in six months to once in two years.

There was increased interest in the neighbourhood for implementing the improved containment.

4.3 Demonstration of Reinforced Cement Concrete Prefabricated Septic Tank

Observations from urban and rural sanitation contexts suggest that many of the Individual Household Latrines (IHHL) constructed under the Swachh Bharat Mission (SBM) use twin-pit containment, regardless of local geological conditions such as a high groundwater table or proximity to water bodies. In Tiruchirappalli alone, the Sanitation Situation Assessment reports that 3,483 IHHLs were built under SBM-Urban, but the report does not clearly disaggregate how many of these use twin pits. ([TNUSSP, 2018](#))

Given these constraints and the potential risk of groundwater contamination from twin-pit systems in sensitive areas an alternative containment solution was explored. Since constructing conventional septic tanks per IS 2470 standards may be cost-prohibitive for poorer urban and rural households, we proposed a reinforced cement concrete (RCC) prefabricated septic tank. While precise market-size data

for RCC prefabricated tanks in Tamil Nadu and Kerala is not publicly available, prefabricated septic units are widely used in various parts of India.

4.3.1 Reinforced Cement Concrete-based septic tank system

This system is made up of RCC circular pipes of NP3-grade for strength and durability and its cost is lower than conventional septic tanks (Check Table 3.3 for cost comparison). For five users, the RCC pipe septic tank has a length of 2.5 m and a diameter of 0.9 m, with an effective depth of 0.75 m, resulting in a total effective volume of 1,200 litres. A partition wall is positioned 0.83 m from the inlet, accounting for a volume of 370 litres in that section. It also includes a 150 mm freeboard for safety and managing overflow. The system is designed to provide a HRT of eight to nine days, ensuring adequate treatment of the waste. The construction is feasible beneath car parking areas, making it a space-efficient and practical solution for onsite sanitation.

4.3.2 Site selection

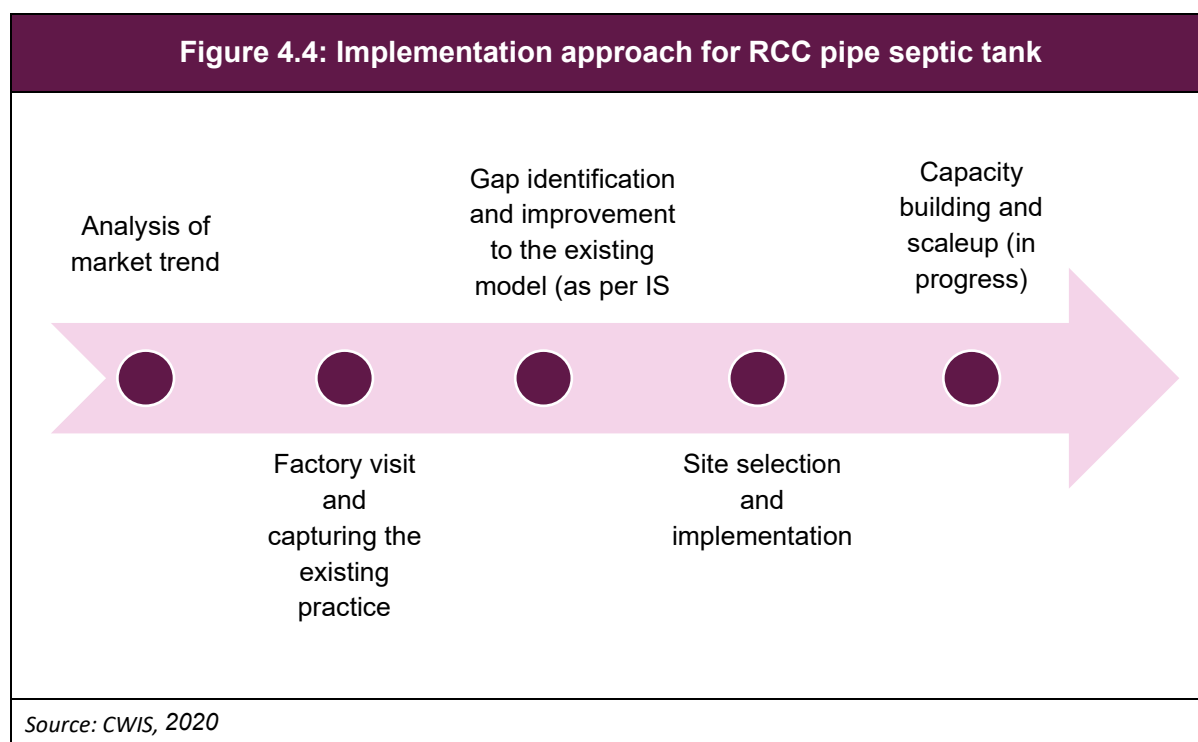
The demonstration was carried out at Kodappu, one of the urban poor settlements in Trichy where UGD has not been laid, and households had issues with containment units.

4.3.3 Assessment of the existing containment system

During the assessment of the household, it was found that it had access to a toilet but did not have a containment system. The outlet from the toilet was connected to a damaged single pit located near a borewell. It was also observed that most septic tank components did not comply with IS 2470 standards, particularly in terms of the provision of baffle walls.

4.3.4 Implementation timeline

The implementation approach for the intervention is depicted in Figure 4.4.



The gaps with respect to the conventional and RCC pipe septic tanks are provided in Table 4.3 below.

Table 4.3: Comparison of conventional and RCC pipe septic tanks		
Description	RCC Pipe (for 5 users)	Septic Tank (for 5 users)
Material	RCC NP3 grade	Brick wall
Dimensions	Length - 2.5 m, Diameter - 0.6 m, Effective Depth - 0.45 m	Length - 1.5 m, Breadth - 0.75 m, Depth -1.3 m, Effective depth - 1.0 m
Total Volume (effective)	545 litres	1125 litres
Distance of the partition wall from the inlet	0.83 m (370 litres)	1 m (No partition wall required for volume less than 2000 litres)
Hydraulic Retention Time	3-4 days	7-8 days
Freeboard	150 mm	300 mm
Construction below car parking	Possible	Possible
CapEx	Approx. INR 27,000	Approx. INR 47,000
<i>Source: CWIS, 2020</i>		

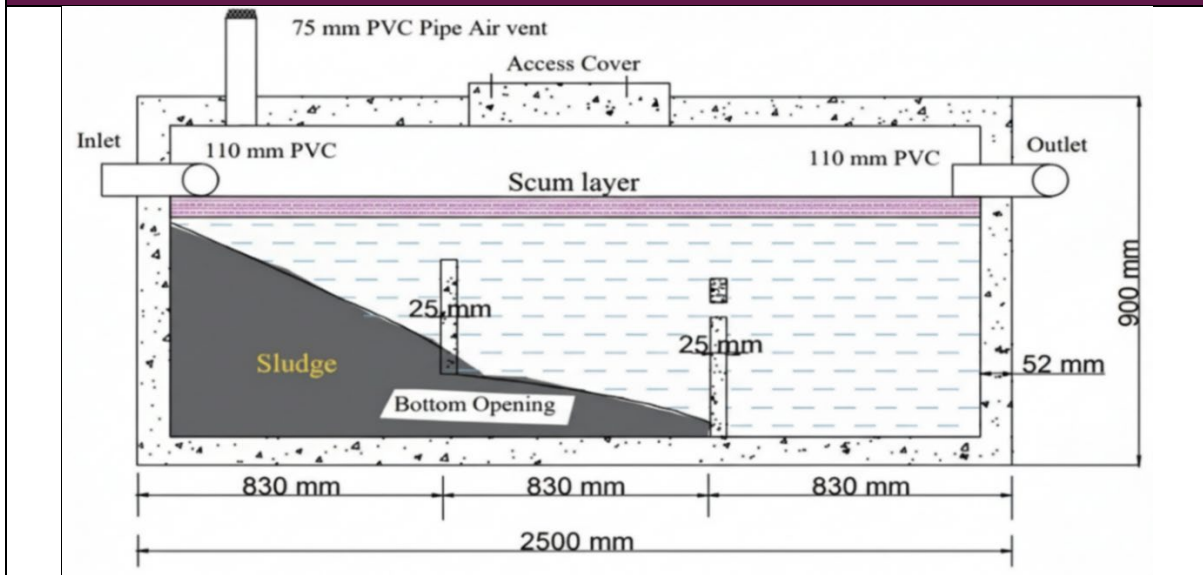
4.3.5 Implementation

The team conducted extensive exposure visits to various RCC pipe septic tank manufacturers before selecting one from Karur whose products best met the requirements. However, gaps were identified in the design, particularly in the provisions for baffle wall openings, placement and inlet and outlet levels, which rendered it inefficient in preventing scum from flowing into subsequent chambers.

The prefabricated septic tank selected for installation was a circular pipe model. To enhance its functionality, it was modified to include appropriate provisions for baffle wall, and inlet and outlet. A T-pipe and two baffle walls were incorporated: the first baffle wall was open at the bottom, and the second was open at the top. Additionally, two partition walls were installed at equal intervals of 0.83 m within the tank. The outlet from the toilet was connected to the tank's inlet, allowing sludge to settle at the bottom while treated water flowed into the outlet chamber. The improved containment system was installed and completed within a single day on 20 April 2022. A longitudinal section of the installed tank is depicted in Figure 4.5 below.

During eight months of monitoring, the intervention exhibited high efficiency, confirming the success of the design and implementation. As effluent overflows were observed in the open drain, an electro-chlorinator was installed in the outlet chamber. It effectively treats the effluent by producing chlorine, which helps disinfect harmful pathogens, ensuring the treated water meets safety standards for discharge into the environment. However, during the monitoring period, it was observed that electro-chlorinator was expensive and had operational challenges. Hence, constructing a soak pit or dispersion trench has been planned for better effluent management and reducing pathogens.

Figure 4.5: Longitudinal section of prefabricated RCC pipe septic tank



Source: CWIS, 2022

Figure 4.6: Installation of RCC pipe septic tank at Kodappu

		
<p>Prefabricated RCC pipe septic tanks</p>	<p>Unloading from the vehicle</p>	<p>Plain Cement Concrete</p>
		
<p>During installation</p>	<p>Installation without the disinfection unit</p>	<p>With Electro-chlorinator disinfection unit</p>
<p>Source: CWIS, 2022</p>		

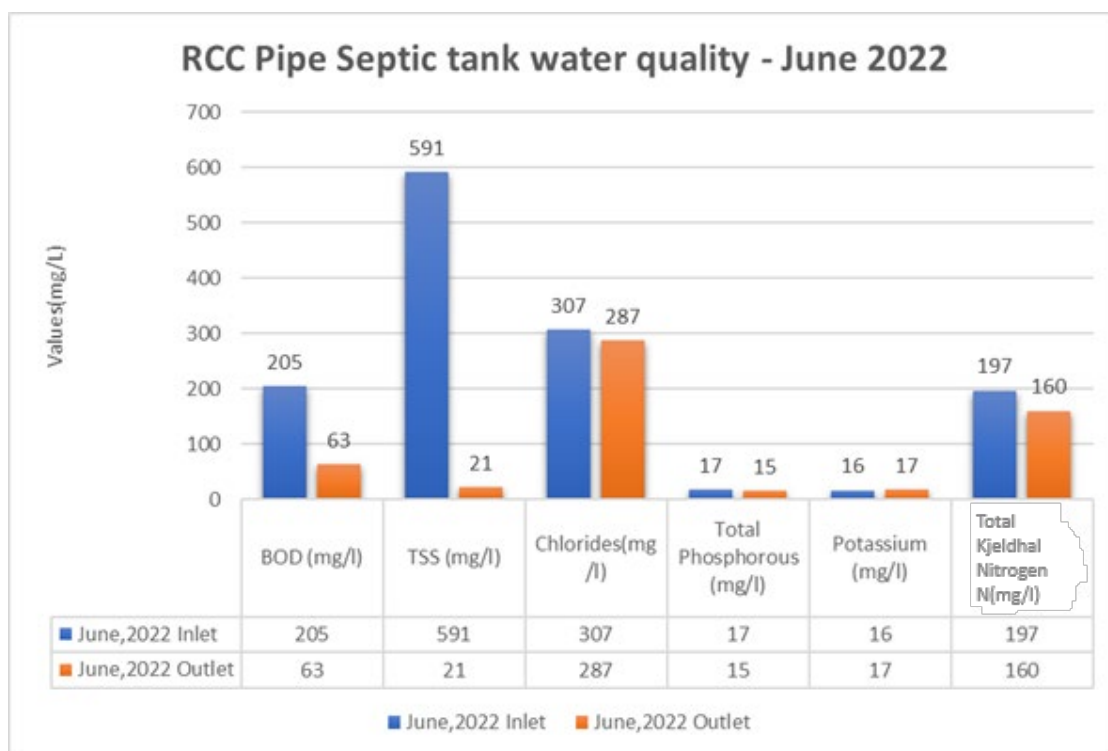
4.3.6 Sampling and analysis

The analysis was carried out at Excellence Lab in Madurai, about 140 km from the sampling point.

4.3.7 Performance

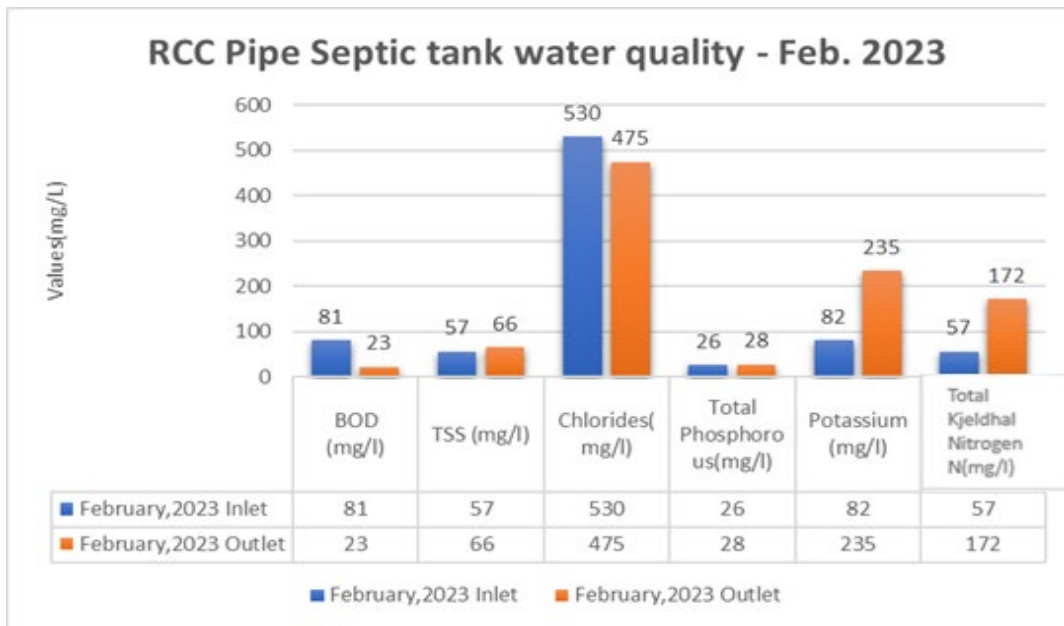
The accumulated sludge depth since installation is 100 mm (4 inches) in over eight months. The expected volume has not yet been accumulated as the desired sludge depth for de-sludging is 40 per cent of the accumulated sludge volume. Hence, de-sludging can be done after another year. The structure was stable since installation. The effluent quality was periodically monitored from the day of installation and subjected to physicochemical analysis. The results depicted a reduction in BOD, COD, TSS, Total Nitrogen, and oil and grease.

Figure 4.7: Performance efficiency of RCC septic tank immediately after implementation



Source: CWIS, 2022

Figure 4.8: Performance efficiency of RCC septic tank a year after implementation



Source: CWIS, 2023

4.3.8 CapEx and OpEx

CapEx for implementation was INR 27,000 which included the supply and installation of RCC pipe septic tank along with its fittings, and conducting hydrostatic test. OpEx for the system is estimated to be INR 1,000 per annum. LCC of the system will be around INR 50,000 - 69,000 based on the estimated lifespan of 15 years. For the detailed breakup, refer to the **Annexure 6**.

4.3.9 Challenges and outcomes

While it was expensive to procure a single unit due to high transportation and unloading costs, the RCC pipe septic tank model (INR 27,000, including all expenses) was found to be more affordable than conventional septic tanks (approx. INR 47,000). Similarly, RCC pipes of various sizes were available which helped the team in working with the space constraints at the site.

The following were the outcomes of the containment improvement:

1. Easy to install and commission
2. Possesses better durability than masonry wall septic tanks
3. Decreased frequency of de-sludging due to low sludge accumulation levels
4. Improved effluent quality
5. Decreased frequency of O&M

4.3.10 User experience

The feedback from the household before and after the improvement illustrates the efficiency of RCC pipe septic tank. The users stated the benefits of the improved containment unit as,

1. Affordable than other OSSs

2. No bad odour
3. Less mosquito breeding
4. Reduced de-sludging frequency
5. Savings in time and cost than conventional septic tank
6. Increase in demand for prefabricated septic tanks from other households

4.4 Earthworm-based Bioreactor

Earthworm-based Bioreactor is considered one of the potential solutions to improve existing OSS. This is a sustainable method in which septage is treated through aerobic decomposition of epigeic earthworms. Vermiculture researchers have identified tiger worm (*Eisenia fetida*), red tiger worm (*E. andrei*), African night crawler (*Eudrilus euginae*), Indian blue worm (*Perionyx excavatus*), and red worm (*Lumbricus rubellus*) to be effective in the treatment of various solid and liquid organic wastes under different climatic conditions. (Sinha et.al, 2009)

4.4.1 Earthworm-based Bioreactor System

As the wastewater flows through a bioreactor, a slime layer (biofilm) is formed on the packing material (Metcalf & Eddy, Inc *et al.*, 2003). Microorganisms secrete extracellular polymeric substances that enable them to form biofilms and attach with the packing material. A microbial community will be established in the form of biofilms within one to three days from the commencement of treatment operation. The biological community formed in the bioreactor includes aerobic and facultative bacteria, fungi, algae and protozoans.

Cocopeat is the packing material for EBR. Earthworms are introduced in the surface layers to graze excess biofilms and prevent the biofilter from clogging. The continuous movement of earthworms loosens the surface layer, thereby allowing airflow by advection and ensuring the prevalence of aerobic conditions in the EBR layers. Hence, biological treatment of wastewater is achieved without the use of external aerators.

4.4.2 Site selection

The demonstration was carried out in three locations—Karumandapam, Ponmalai, and Vengur—based on the site conditions and types of containment units. These locations had high water table which created suitable conditions for the growth and activity of earthworms.

4.4.3 Observations

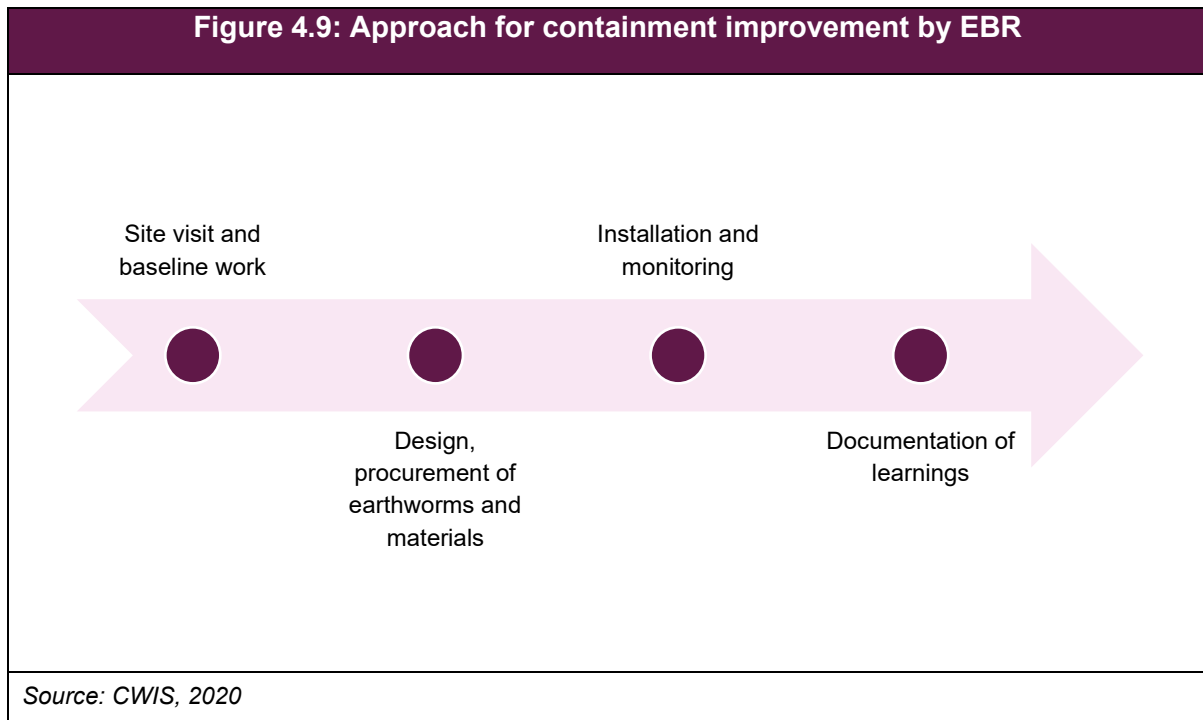
OSS 1: The OSS at Karumandapam was a septic tank with three chambers and a dispersion pit. Observations showed damaged septic tank, broken top slabs, and absence of vent pipe.

OSS 2: The existing OSS at Ponmalai was a leach pit which got flooded with water due to heavy rain. Additionally, excessive infiltration caused system collapse and blockage.

OSS 3: The OSS at Vengur was a septic tank with soak pit. The effluent from septic tank was not dispersing into the soil as it was a flood-prone region.

4.4.4 Implementation timeline

The approach for EBR is shown in Figure 4.9.









4.4.5 Implementation

Existing OSS in the selected sites were de-sludged and refurbished, as required, to install the EBR. The conceptual diagram of EBR system for septic tank or holding tank and single pit are illustrated in Figures 4.10 and 4.11.

4.4.5.1 Earthworm-based Bioreactor

EBR was assembled in a plastic barrel capacity of 200 litres of 55-centimetre (cm) diameter and 80 cm depth, and the effluent from the barrel was drained through a layer of washed aggregates (10-15 cm thick). Holes were provided throughout the circumference of the barrel at about 10 cm from the bottom. The earthworm-vermicompost mixture (a combination of *Eudrilus eugeniae* and *Eisenia fetida* species) was introduced after the barrel was placed in OSS. Cocopeat blocks with low electrical conductivity (EC) were used as the active biological layer. For a better understanding, the steps involved in the preparation of EBR is provided in Figure 4.10.

Figure 4.10: Preparation of an EBR

		
<p>PVC drum with drain holes</p>	<p>Inner view</p>	<p>Drainage layer</p>
		
<p>Drainage and mesh layer</p>	<p>Installation after addition of earthworm-vermicompost mixture</p>	<p>Bioreactor after installation in the containment</p>
<p>Source: CWIS, 2020</p>		

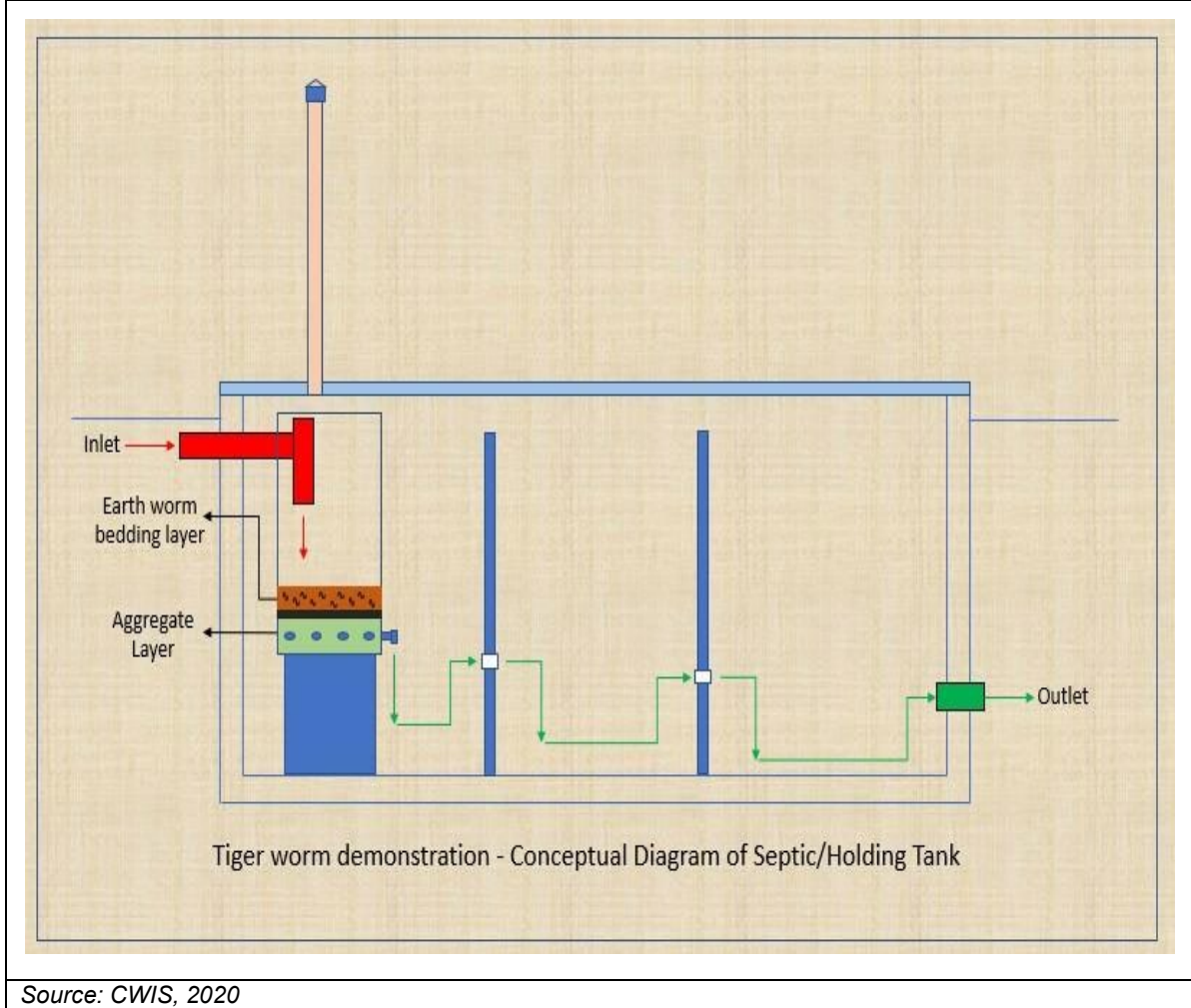
4.4.5.2 Digester for EBR

The construction of digesters for bioreactors varied slightly for septic tanks and single pits, and the specifications are elaborated below.

Digester for septic tanks

For septic tanks, the first chamber was converted to EBR. It incorporated a 200-litre barrel (smaller than septic tank's inner size) and was supported with RCC rings at the bottom to adjust the height. The barrel was fitted with a layer of drain system and mosquito net to prevent the worms from escaping. A 200 to 300 mm thick layer of cocopeat with earthworms was placed over the net. The set-up is depicted in Figure 4.11.

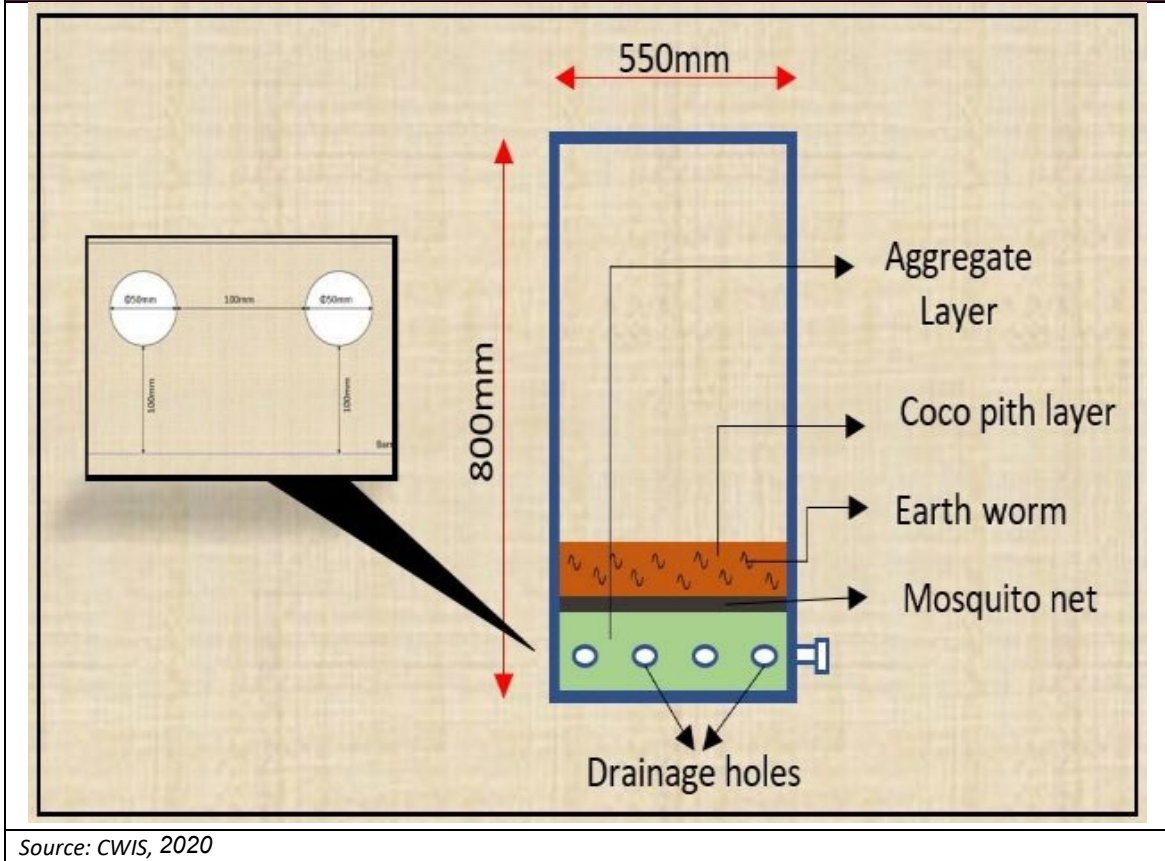
Figure 4.11: Conceptual diagram of EBR for septic tanks



Digester for single pits

Single pit was converted to EBR by placing a 200-litre barrel (smaller than pit's inner size) and was supported with RCC rings at the bottom to adjust the height. The barrel was fitted with a layer of drain system and mosquito net to prevent the escape of worms. A 200 to 300 mm thick layer of cocopeat with earthworms was placed over the net as depicted in Figure 3.11.

Figure 4.12: Conceptual diagram of EBR for single pits







4.4.6 Sampling and testing

The EBR demonstrations were studied over a period of three months (October to December 2020). Effluent sampling was initiated one week after EBR commissioning, based on Oxidation Reduction Potential (ORP) values. Sampling was conducted regularly throughout the three-month period, using a small pump and an in-house water sampler, with collected samples stored in an icebox.




4.4.7 Performance

The baseline effluent from containments were measured for COD, TS, TSS, TDS, TVS, total nitrogen, total phosphorus, and E. coli based on standard methods.

OSS 1 (Karumandapam): The EBR, fitted in the first chamber, failed to function due to anaerobic conditions. This was possibly due to a thick microbial biofilm on septic tank walls which killed worms by outer skin peeling (outer skin burst).

Figure 4.13: EBR at Karumandapam			
			
Containment before improvement	After cleaning the site	During implementation	Failed system
Source: CWIS, 2023			

OSS 2 (Ponmalai): The EBR was functional with proper drainage but failed on day 12 due to shock loading as there was a spike in the number of users in the household. Fecal solids accumulated on the surface layer of the bioreactor possibly hindered the free draining of water. Hence, water became stagnant and caused the worms to drown.

Figure 4.14: EBR at Ponmalai		
		
Containment before improvement	During implementation	Failed system with stagnation
Source: CWIS, 2023		

OSS 3 (Vengur): After installation, the containment was flooded due to rain. Also, heavy infiltration led to collapse and blockage of the system.

Figure 4.15: EBR at Vengur

			
Containment before improvement	During implementation	After implementation	Failed system with stagnation
Source: CWIS, 2023			

4.4.8 CapEx and OpEx

CapEx for the implementation was INR 2,000 to 5,000 which included supply and installation of Poly Vinyl Chloride (PVC) drums, pipes and EBR with drainage system. OpEx for the system is estimated to be in the range of INR 3,000 once in 5 years and LCC will be around INR 35,000 - 37,000 based on the estimated lifespan of 15 years. For the detailed breakup, refer to **Annexure 5**.

4.4.9 Challenges and outcomes

The challenges in the demonstration model were,

1. Maintaining comfortable environment for earthworms to survive in the anaerobic conditions.
2. Difficulty in disposing of the effluent without pumping arrangements as the level of EBR was 1 m lower than the existing outlet level.
3. Inadequate area for the earthworms in EBR.
4. Difficulty in monitoring earthworm-based treatment systems due to their sensitivity to environmental conditions, biological variability and complex interactions with microorganisms and organic matter.
5. Requires frequent maintenance and skilled supervision due to prevalence of issues like clogging, environmental impacts, and unavailability of standardised tools.
6. Difficulty in controlling the escape of earthworms.

The demonstration indicated the failure of the EBR system due to anaerobic conditions in the bioreactor, leading to the death of earthworms. The anaerobic conditions were possibly due to microbial film on the walls which should be removed before the addition of earthworms. Ensuring sufficient drainage from the EBR even during peak loading is necessary to prevent system failure. This model may not be suitable for flood-prone areas, and if required, specific steps must be carried out to prevent the entry of water from external environment, especially for unlined pits.

4.4.10 User experience

The feedback collected from the households before and after the improvement are listed below.

1. The system ran without issues for a few days.
2. Bad odour emanated from the EBR when the number of users increased on a particular day at leach pit site (OSS 2).
3. Earthworms escaped from the EBR.
4. It was difficult to maintain the system.

In accordance with the consent obtained from the households, the original OSS was restored at the households due to the failure of the intervention.

4.5 DRDO Biodigester with patented bio-culture

The Defence Research and Development Organisation (DRDO) developed a biodigester-based containment model for safe disposal of human waste in remote areas that do not have access to conventional sewage systems. The technology uses anaerobic bacteria to break down waste into water and gases, which can be safely discharged into the environment. This model demonstrated its viability in improving existing septic tanks and single pits.

4.5.1 DRDO biodigester system

The Nirgandh biodigester treatment system was selected for this study due its affordability. It operates on the principle of anaerobic digestion, using specialised bacteria that break down organic waste in septic tanks. These bacteria decompose organic matter into simpler compounds like methane, carbon dioxide, and water, thereby reducing the volume of solid waste and sludge accumulation. The system effectively controls odours, produces cleaner effluent, and requires minimal maintenance. By maintaining self-sustaining bacterial activity, the Nirgandh model offers an eco-friendly, cost-effective solution for septic tank treatment, reducing pollution and improving waste management efficiency.

4.5.2 Site selection

As a part of the study, DRDO model was implemented at three different locations—two households at Karumandapam and the third one located at Keela Panjapur. Based on the assessment and gap analysis, the required prefabricated digesters made of Fibre Reinforced Plastic (FRP), High Density Polyethylene (HDPE) and RCC have been procured, modified and installed at the site.

4.5.3 Observations

In the existing containments, walls were leaking and the units did not have a proper disposal arrangement. The wastewater was directly disposed of into the soil, leading to bad odour. Pits were located near a water body and did not have an outlet. Consequently, de-sludging was carried out once in six months.

Table 4.4: Comparison of containments at sites identified for DRDO Biodigester implementation

Description	Household 1 at Viswas Nagar, Karumandapam	Household 2 at Alpha Nagar, Karumandapam	Household 3 at Keela Panjapur	Status
Containment type	Septic tank	Holding tank	Single pit	-
Size	<ul style="list-style-type: none"> 3 m x 1.23 m x 2 m Effective depth - 1.67 m 	<ul style="list-style-type: none"> 3 m x 1.5 m x 2.75 m Effective depth - 2.36 m 	<ul style="list-style-type: none"> Inner diameter - 0.9 m Overall depth - 1.6 m Effective depth - 1.4 m 	Meets requirements
Inlet and outlet	<ul style="list-style-type: none"> No 'T' pipes Inlet height - 1.75 m Outlet bottom limbs - 1.67 m 	<ul style="list-style-type: none"> No 'T' pipes Outlet not connected to any disposal system 	<ul style="list-style-type: none"> Inlet visible and located above GL No 'T' pipe No outlet 	'T' pipe provision required
Access openings	<ul style="list-style-type: none"> No openings or manholes Cover slabs to be removed 	<ul style="list-style-type: none"> No openings or manholes Cover slabs to be removed 	<ul style="list-style-type: none"> No openings or manholes Cover slabs to be removed 	Need to provide access holes at cover slabs
Partition wall	<ul style="list-style-type: none"> Two partition walls Corroded plastering above water level 	Two partition walls, damaged	N. A	Damaged
Vent pipe	Broken, provided at the outlet side	<ul style="list-style-type: none"> Provided at the inlet side Height - 2.5m 	Hole provided at the cover slab for the air vent but no air vent pipe	Damaged
Condition of wall, floor, and cover slab	<ul style="list-style-type: none"> Undamaged brick wall Plastered inner and partition walls 	<ul style="list-style-type: none"> Outer wall - 0.23 m thick brick work Undamaged plastered inner and partition walls 	<ul style="list-style-type: none"> Constructed using concrete rings 50 mm thick wall 	Damaged

Table 4.4: Comparison of containments at sites identified for DRDO Biodigester implementation

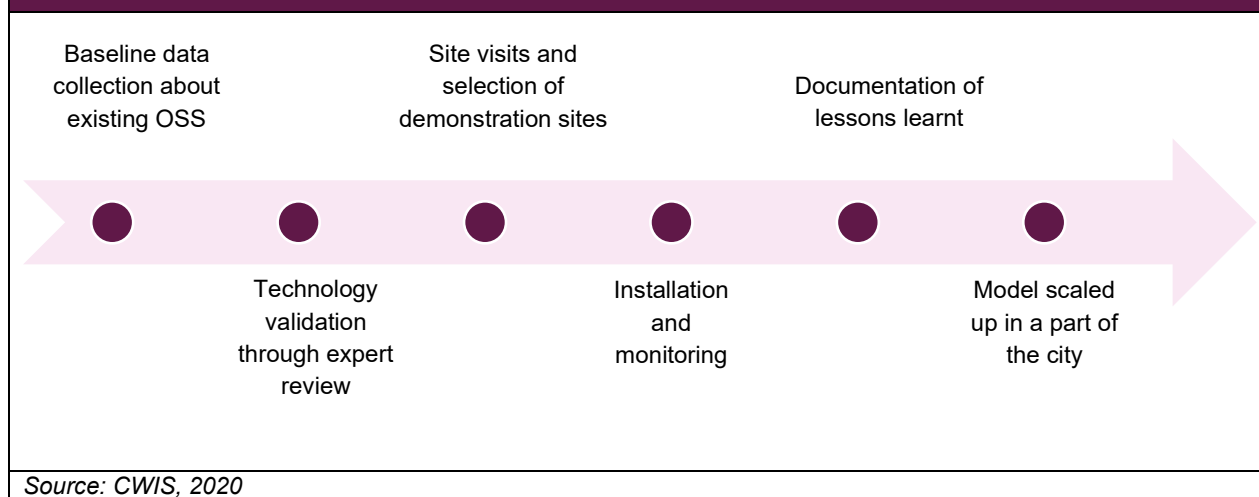
Description	Household 1 at Viswas Nagar, Karumandapam	Household 2 at Alpha Nagar, Karumandapam	Household 3 at Keela Panjapur	Status
Containment type	Septic tank	Holding tank	Single pit	-
	<ul style="list-style-type: none"> Corroded plastering above inlet pipe Broken and corroded cover slab 	<ul style="list-style-type: none"> Concreted floor in good condition Undamaged cover slab 	<ul style="list-style-type: none"> Damaged precast cover slabs 	

Source: CWIS, 2023

4.5.4 Implementation timeline

The timeline for the implementation is depicted in Figure 4.16. Site visits and baseline studies were conducted from January 2020 to March 2020, and the implementation was done between December 2020 and January 2021. The work was delayed due to COVID-19 protocols.

Figure 4.16: Approach for DRDO Biodigester implementation



Source: CWIS, 2020

4.5.5 Implementation

Prior to the implementation, the selected containment units were de-sludged and disinfected.

4.5.5.1 Household 1 at Viswas Nagar, Karumandapam

The septic tank containment unit was below the ground level and covered by soil and construction waste. The groundwater table was observed to be high at 10 m from the ground level.

As the cement inlet pipe was broken, it was extended with a PVC pipe. To connect with the inlet pipe at 1.75 m from the ground, 20 cm of the digester's first partition wall was broken to reduce its height from 1.85 m.

The containment was dewatered the next day due to seepage of groundwater. Once the installation of the digester was completed, 300 litres of inoculum liquid was poured and the digester was closed. To avoid spillage, the inoculum liquid was poured inside the water closet. Air vent pipes were extended up to 2 m from the top of the containment. After installation, cover slabs were replaced and plastered.

4.5.5.2 Household 2 at Alpha Nagar, Karumandapam

The containment at the household was a holding tank. The implementation began with the marking of levels. The floor height was raised by 5 cm using coarse aggregates to support the digester and ensure proper installation. The digester was carefully placed in the second chamber of the unit using ropes. The existing inlet pipe was replaced due to leakage and connected with the digester. The outlet was extended to enable the effluent to fill inside the containment. A motor was placed in the third watertight chamber to lift the treated water. Further, an up-flow anaerobic filter and vertical reed bed system were installed for secondary treatment.

4.5.5.3 Household 3 at Keela Panjapur

The containment in this household was a single pit, which was filled with coarse aggregates up to a height of 55-60 cm. A 200-litre HDPE barrel was placed inside and connected to the inlet.

Containment pits were excavated nearby for second and third chambers and filled with Plain Cement Concrete (PCC) for a thickness of 150 mm. Multiple cement rings were placed, and fresh cement mortar was used to seal the gaps. The barrel outlet was connected to the second chamber which was connected to the third chamber. The outlets were extended up to the bottom of the chamber, and a soak pit was constructed near the third chamber.

The implementation of the interventions at the selected households is shown in Figures 4.17, 4.18 and 4.19.

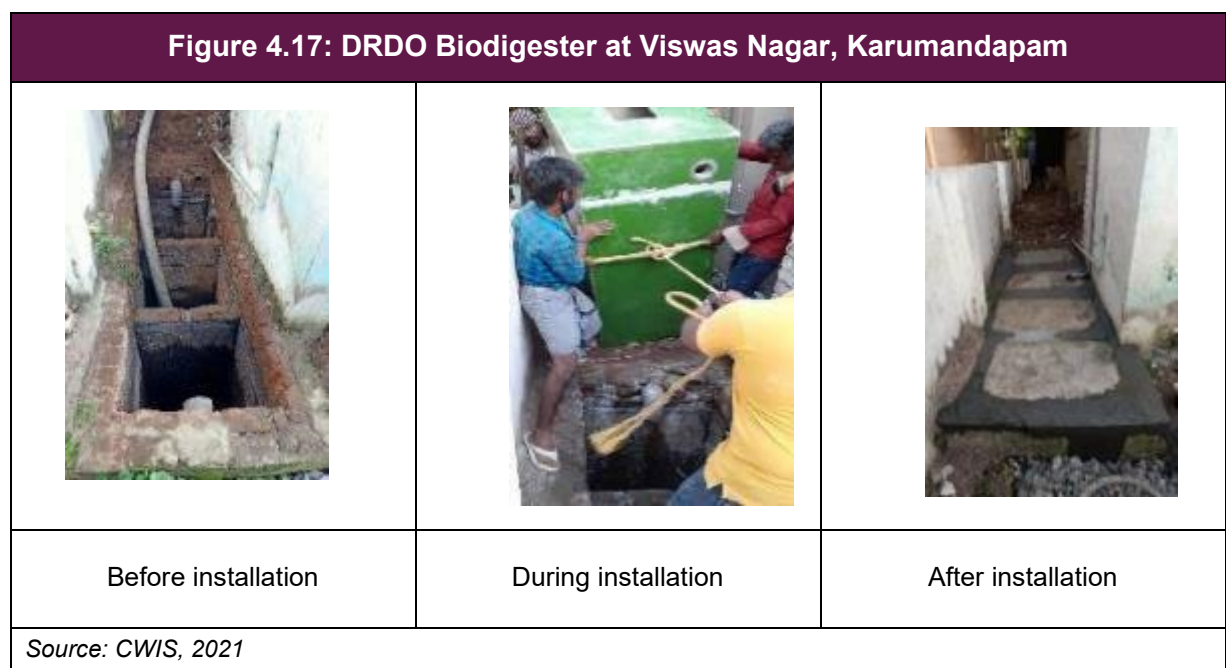


Figure 4.18: DRDO Biodigester at Alpha Nagar, Karumandapam

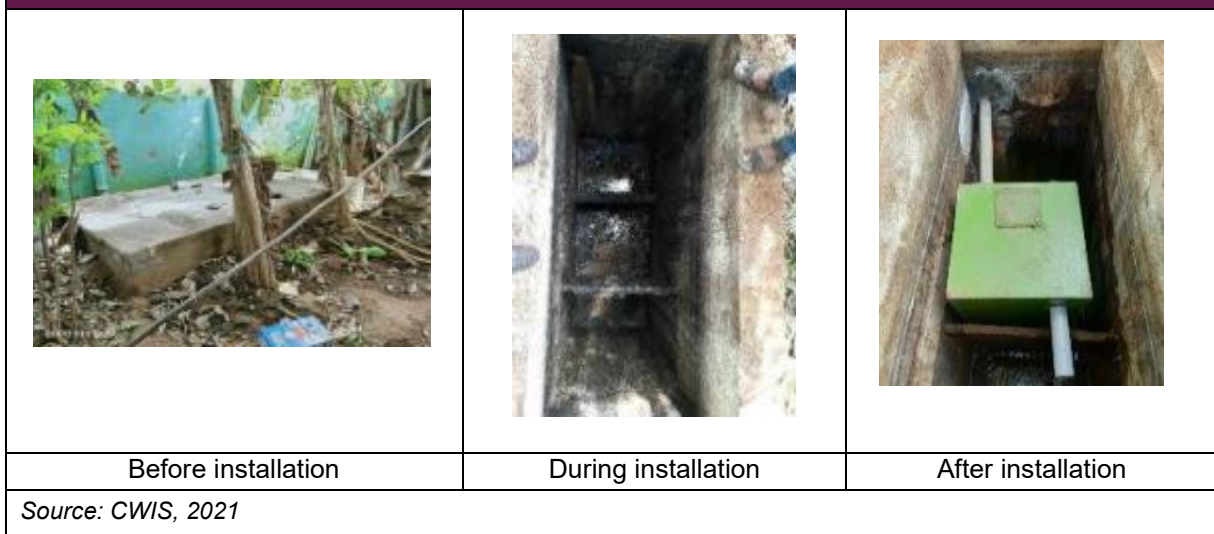
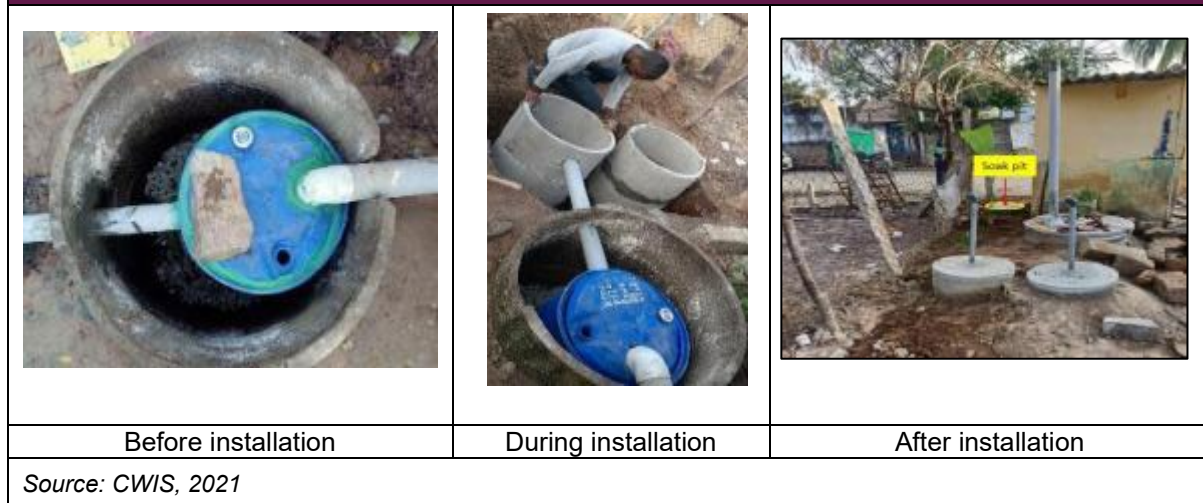


Figure 4.19: DRDO Biodigester at Keela Panjapur



4.5.6 Sampling

A sampling frequency of one month was fixed. The reaction period for the bacteria to multiply and the initiation of fecal sludge digestion typically occurs within one to two months. During this period, the anaerobic bacteria start adapting to the environment by colonising the waste and breaking down organic matter. The biodigester system gradually stabilises, allowing efficient decomposition of the organic content in the fecal sludge. The initial observations were carried out a month after commissioning, and further sampling was carried out based on the advice of the technology provider.

4.5.7 Performance

Figures 4.20, 4.21 and 4.22 show the performance efficiency of the intervention at the respective sites.

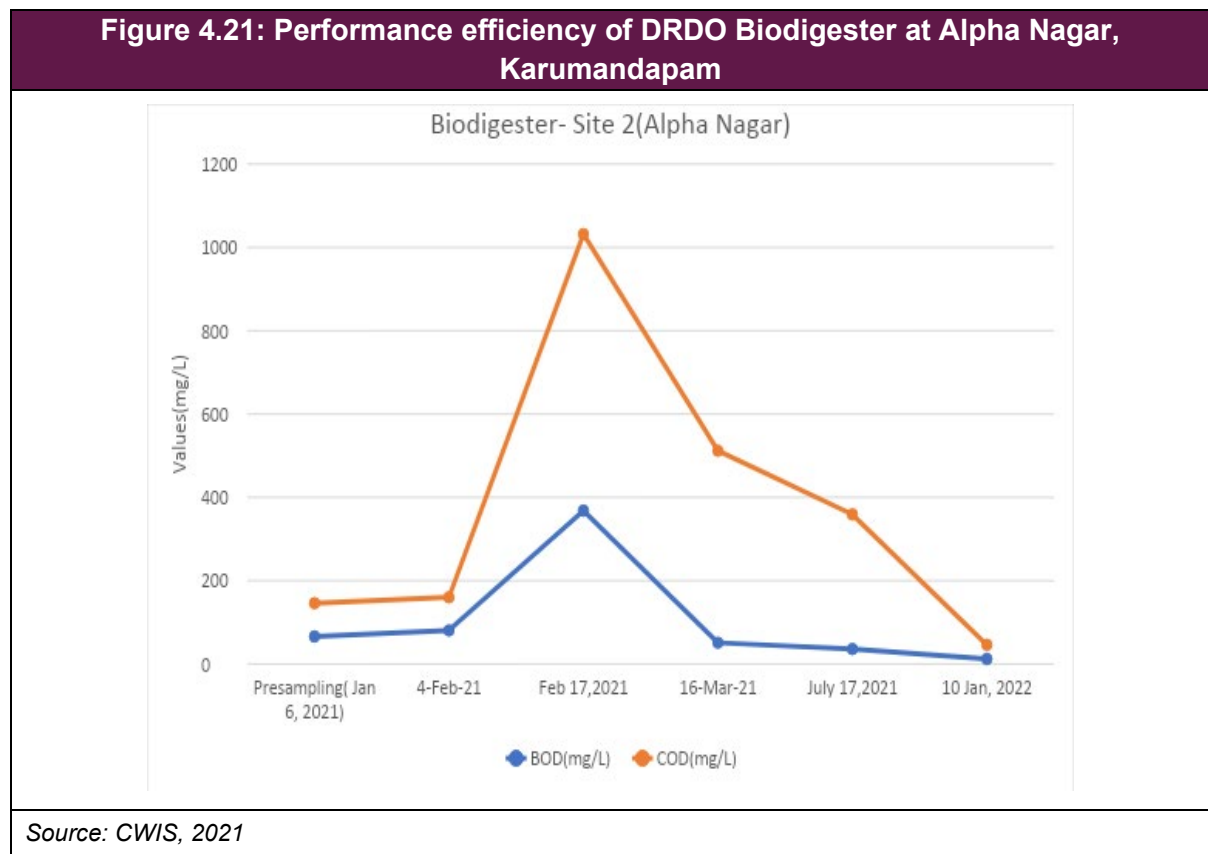
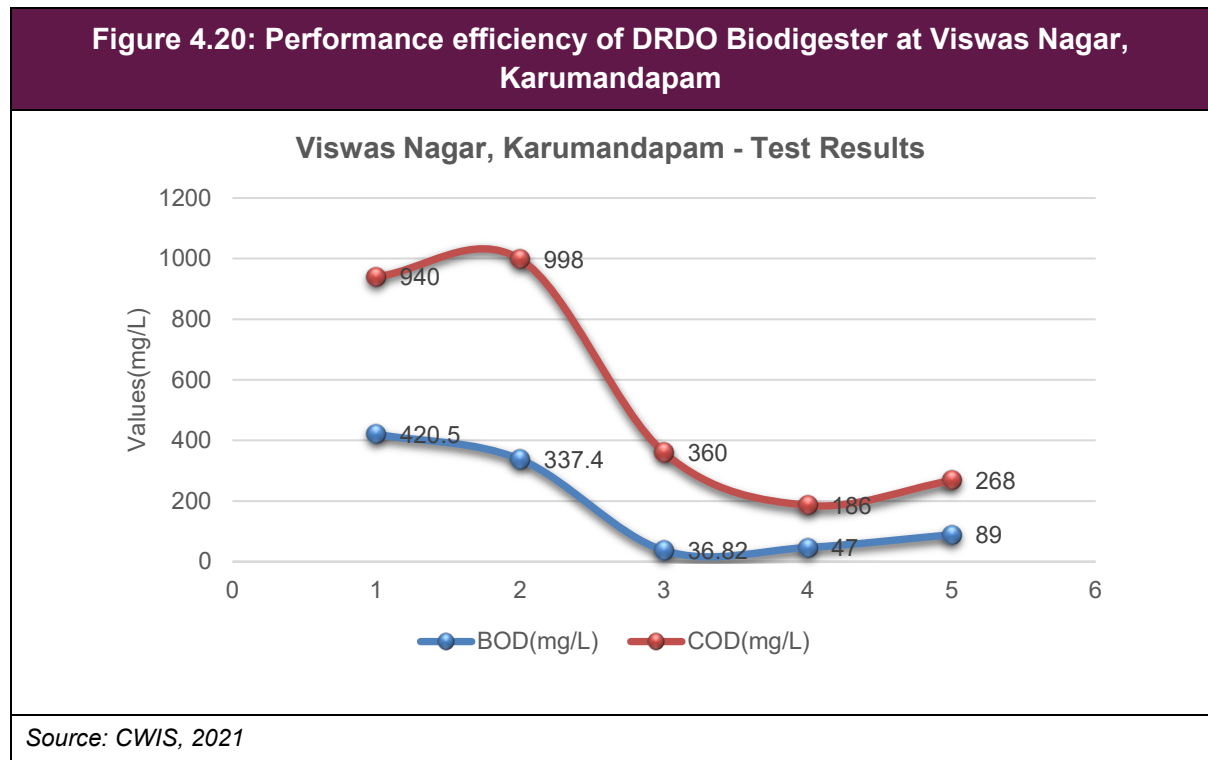
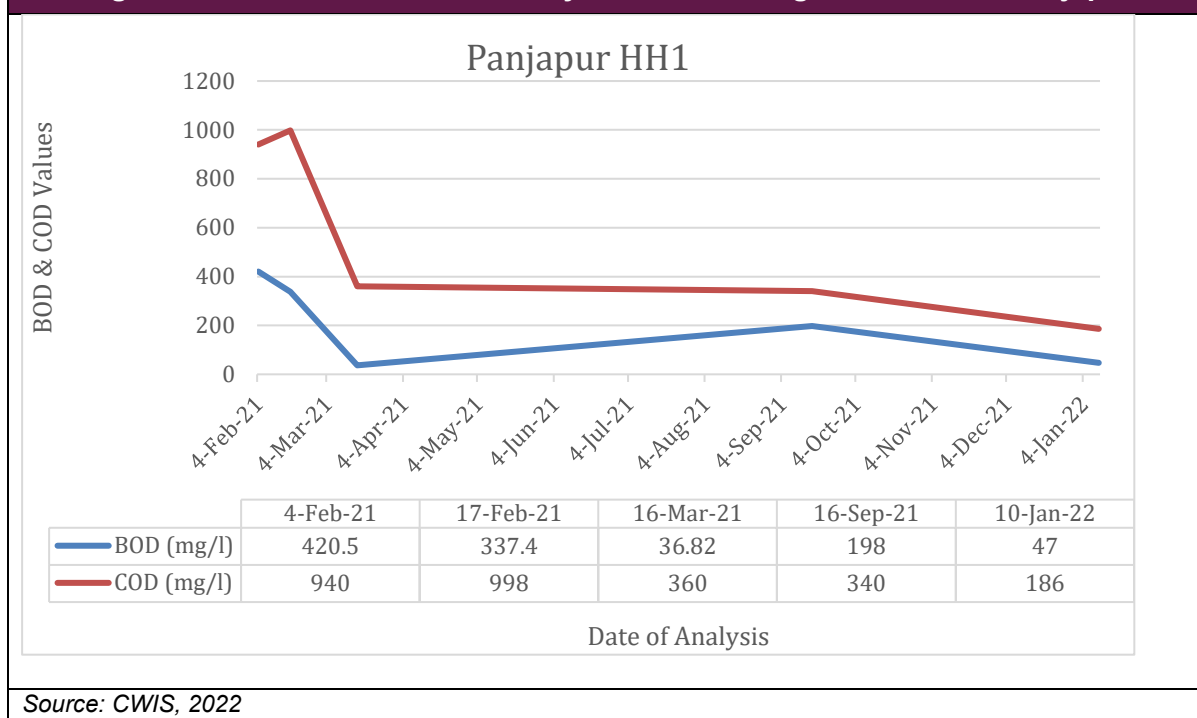


Figure 4.22: Performance efficiency of DRDO Biodigester at Keela Panjapur



4.5.8 CapEx and OpEx

CapEx for the implementation was INR 11,000–38,000 which includes the supply and installation of RCC or FRP tanks, bacterial enzymes, and pipes and fittings. OpEx for the system is estimated to be in the range of INR 2,000–6,000, once in 2 years. LCC of the system will be around INR 35,000–93,000 based on the estimated 15-year lifespan. Detailed estimates are attached in **Annexure 6**.

4.5.9 Challenges and outcomes

The model was found to be easier to install compared to other models, and the acceptance levels was higher among households. During the implementation, there was no restriction on the use of specific cleaning agents for toilets, which was found to have no impact on the functioning of the system. After the intervention, the system was working well without adding enzymes.

The challenges from the demonstration are,

1. High cost of enzymes and FRP panel (estimated around INR 50/litre)
2. Saturation period of two to three months for improvement in the quality of effluent water
3. Difficulty in selecting reputed agencies among many market players

The following are the benefits of the demonstration:

1. Six times lesser area requirement for the biodigester than conventional septic tanks
2. Provision for additional treatment such as an anaerobic filter or planted gravel filter in the remaining area of existing containment
3. Easy to retrofit damaged containment
4. Greater public acceptance of improved version of RCC ring-biodigester

4.5.10 Outcomes

The feedback from the household is listed below,

1. No bad odour
2. Easy to execute
3. No control on chemical use
4. Uses less area as compared before
5. No leakage from the biodigester
6. No de-sludging done (2 years completed)

4.6 Effluent Treatment using Chlorine Tablet System

IS 2470 guidelines recommend the safe disposal of septic tank effluent into the soil, focusing on maintaining acceptable quality standards for BOD, TSS, and pH. The guidelines aim to promote safe and sustainable effluent disposal practices to protect public health and environment. It emphasises the use of soil absorption systems, such as leach fields, to ensure effective percolation and filtration, reducing environmental risks and groundwater contamination. In case of absence of a provision for onsite disposal, proper disinfection after filtration must be carried out before discharging.

The TNUSSP baseline study (2016) showed that many households had constructed OSS without proper disposal arrangements. Moreover, partially treated wastewater from the OSS was released into rainwater drains without disinfection. The presence of fecal coliform in rainwater drains poses a bigger challenge in terms of safe handling and disposal than handling effluent water from septic tank. A simple intervention of providing a chlorine tablet feeding system in the discharge line, along with a contact tank, reduces the pathogen level count to almost Nil.

4.6.1 Chlorine Tablet System

Chlorine Tablet System (CTS) is a simple, feasible and efficient disinfection solution for partially treated wastewater, and is best suited for households as it has a low cost of maintenance and can be operated by the household directly, without the need for skilled expertise.

Adaptation of CTS showed improvements in containment and upscaling of existing systems. The closed-loop CTS system is connected to the outlet line of existing septic tanks, and consists of a contact chamber with a tablet feeder that dispenses one tablet at a time. When the effluent flows through the chamber, the tablet in the feeder comes in contact with the wastewater. The chlorinated effluent is retained in the chamber till the disinfection reactions are completed. The consumption rate of chlorine tablets was 7.0 to 8.0 g/day, and a residual chlorine of 2-5 mg/l was maintained. However, higher tablet dissolving rates resulted in higher operational costs for the system.

4.6.2 Site selection

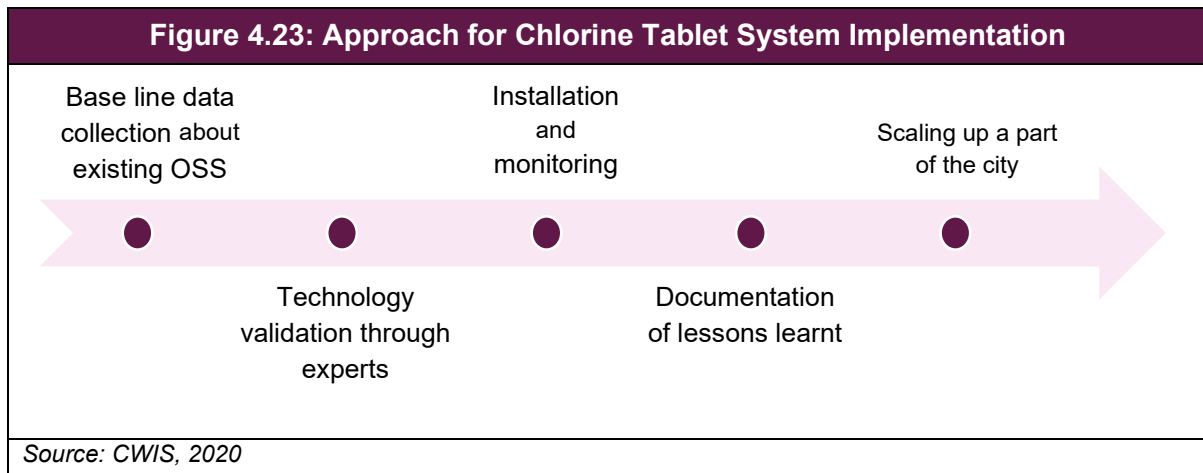
For this study, a site in Kodappu, an urban poor settlement without UGD connection, was selected. As this site also required sanitation improvement, it was suitable for demonstrating the CTS model.

4.6.3 Observations

The household was disposing of the effluent into stormwater drain, and the effluent discharge had a pathogen level count of 10^4 . The stormwater drain had bad odour and mosquito presence due to which the household had difficulty in using the space near the drain.

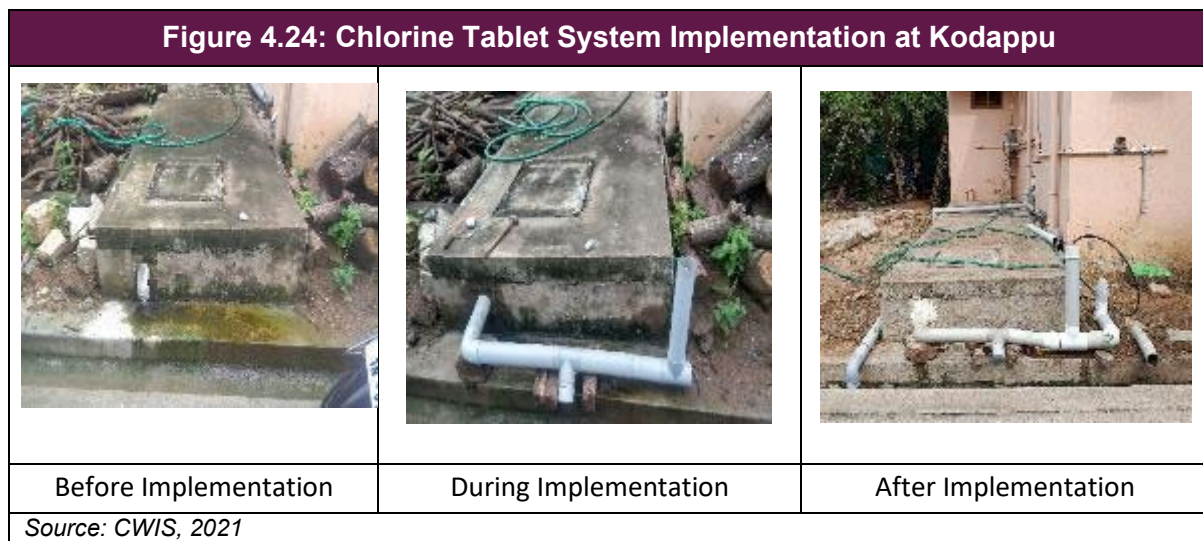
4.6.4 Timeline and Gap Improvements

The timeline for the implementation of the intervention is depicted in Figure 4.23.



4.6.5 Implementation

The closed-loop CTS features a chlorine tablet feeder with a single-feed tube and a contact chamber. As water flows through the chamber, the chlorine tablets gradually dissolve, disinfecting the partially treated wastewater. Demonstration of CTS was carried out during January 2021.



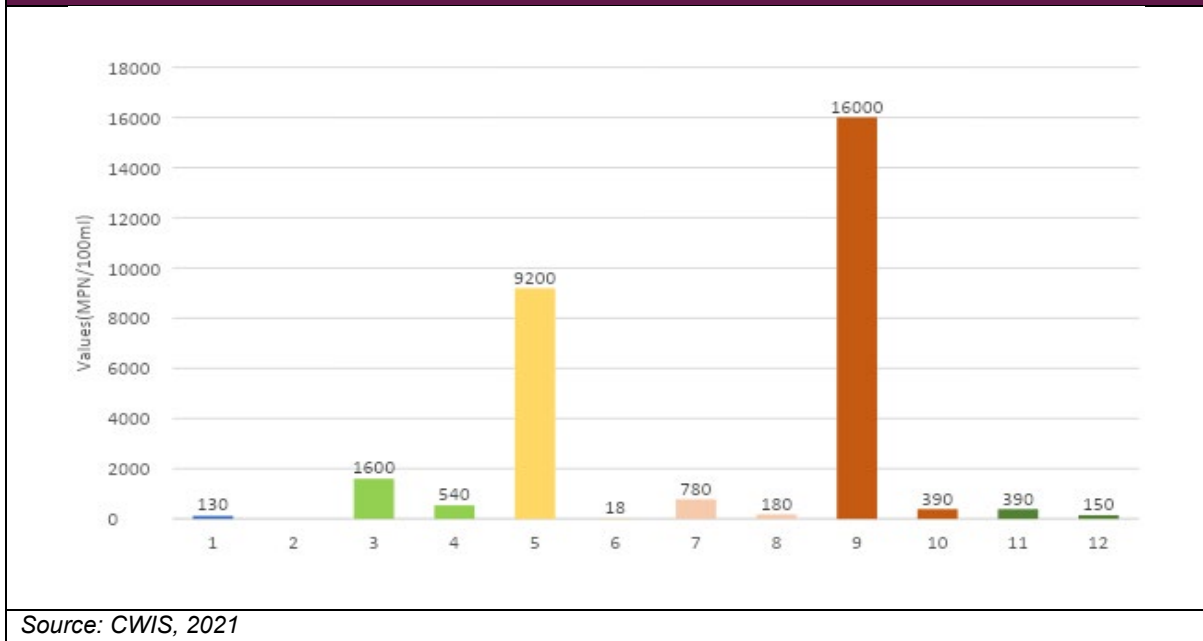
4.6.6 Sampling

Since this is a disinfection system, sampling was done weekly in the beginning and decreased to once a month after a few months.

4.6.7 Performance

Significant reduction in E. coli presence was observed from the samples collected from the outlet of the system.

Figure 4.25: E. coli removal efficiency of Chlorine Tablet System



4.6.8 CapEx and OpEx

The CTS incurs an estimated annual operating cost of INR 530–850, primarily for chlorine tablets used once a year or as needed. Initial installation costs are approximately INR 3,615, while operating costs over a 15-year lifespan amount to around INR 13,000. Repairs or replacements, including de-sludging and minor pipeline rectifications could cost INR 2,000–4,000. Thus, the total life cycle cost for this system ranges between INR 19,000 and INR 21,000, subject to site-specific variations. For detailed estimates, refer to **Annexure 6**.

4.6.9 Challenges and outcomes

The study reveals that despite reduction in pathogen level in septic tank effluent, following challenges was faced during the implementation,

1. Initial lack of understanding on the need for CTS among the public.
2. Scarce availability of the right chlorine tablet at the household level.
3. Limited life of electronic components such as automatic timer.
4. Intangibility of direct benefits, i.e., no physical representation of benefits due to reduced E. coli presence.
5. Requirement of skilled persons for the implementing the model.

4.6.10 Outcomes

The outcomes of the demonstration were,

1. No by-product of disinfection from treated water
2. Better disinfection efficiency
3. Ease of operation and retrofitting

4.6.11 User Experience

The feedback from the users were,

1. Reduced bad odour caused by effluent discharge
2. Less mosquito breeding in drains

Summary and Scalability

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5. Summary and Scalability

5.1 Introduction

This section presents an overview of the containment improvement technologies demonstrated under the CWIS programme. It discusses the performance, cost, and implementation outcomes of each model, followed by an assessment of their potential for replication and scale-up across different urban contexts in Tamil Nadu.

5.1.1 Reflections

The demonstration of containment improvement technologies provided valuable insights into their feasibility, cost and operational efficiency. Household-level models such as the IS 2470-compliant septic tank and RCC pipe septic tank were cost-effective and easier to replicate, while the DRDO biodigester showed better user acceptance and reduced maintenance needs. However, technologies like the EBR faced challenges in sustaining performance due to varying environmental conditions. At the bulk generator level, implementing improved septic tanks integrated with anaerobic reactors required higher investment and technical oversight, limiting scalability without dedicated institutional support.

5.1.2 Scalability

The containment improvement models demonstrated in Trichy show varying levels of scalability depending on their technical complexity, cost, and operational requirements.

At the household level, interventions such as IS 2470-compliant septic tanks, RCC pipe septic tanks and DRDO biodigesters have demonstrated potential for replication. Their relatively low construction costs, ease of installation, and limited operational needs make them suitable for adoption across other urban settlements with similar site conditions. Particularly, prefabricated RCC pipe tanks can be rapidly scaled through partnerships with local manufacturers, while the DRDO biodigester offers a viable alternative for areas with high water tables or space constraints. Technologies such as the EBR showed limited scalability due to maintenance challenges, sensitivity to environmental conditions, and the need for skilled supervision. However, with design refinements and performance standardisation, this model could serve as a sustainable solution for small households under controlled settings.

At the bulk generator level, large-scale systems combining improved septic tanks, ABR and AF are effective but capital-intensive. Since these systems do not require continuous monitoring and have minimal O&M needs, their replication is feasible in institutional or CT settings, provided there is strong engagement from Urban Local Bodies (ULBs) and adequate budgetary support.

The following table presents a comparison of the demonstrated containment technologies.

Table 5.1: Comparison of containment improvement technologies demonstrated in Trichy

Household-level Demonstrations						Bulk Generator-level Demonstrations	
Descriptions	Improvements as per IS 2470	RCC pipe septic tank	EBR	DRDO Biodigester	CTS	Improved Septic Tank + ABR + AF + Disposal (For 7 KLD)	EBR
Construction cost (INR)	25,000 to 40,000	27,000	2,000 to 5,000	12,000-55,000	3,000 to 8,000	4,40,000	1,42,000
Operation cost (INR)	2,500 once in 3 years	2,000 once in 2 years	3,000 once in 5 Years	2,000 once in 2 years	~1,000 per annum	15,000 per annum.	6,000-10,000 per annum
Life cycle cost	68,000 - 85,000	50,000-69,000	36,000 - 37,000	61,000 - 91,000	19,000 - 26,000	4,80,000 – 8,38,000	1,66,000 – 2,10,000
Area requirement (sq. m)	6	1.4	1	1	<1	80	5
Name of the implementing agency	Local	Local	Humus India Limited LLP	Nirgandh (DRDO patented)	Local	Local	Humus India Limited LLP
Status of the work	Completed	Completed	Completed	Completed	Completed	Completed	Completed
<p><i>For households (IHHT): All the options were designed for 8 users per day</i> <i>For bulk generators (CT/PT): Design is based on site condition and number of users</i></p>							
<p><i>Source: CWIS, 2021</i></p>							

5.2 Way forward

To enable large-scale adoption of these technologies, the following key actions are recommended:

- **Institutional support:** Integrate containment improvement models into municipal sanitation plans and capital investment frameworks.
- **Technical capacity:** Strengthen local mason and contractor skills on standard design and construction practices as per IS 2470.
- **Financial mechanisms:** Introduce targeted subsidies, credit options or incentive schemes for households and bulk generators adopting improved systems.
- **Performance monitoring:** Establish a periodic monitoring framework for effluent quality and structural stability.
- **Awareness and behavioural change:** Promote public awareness on safe containment, periodic de-sludging, and system upkeep.

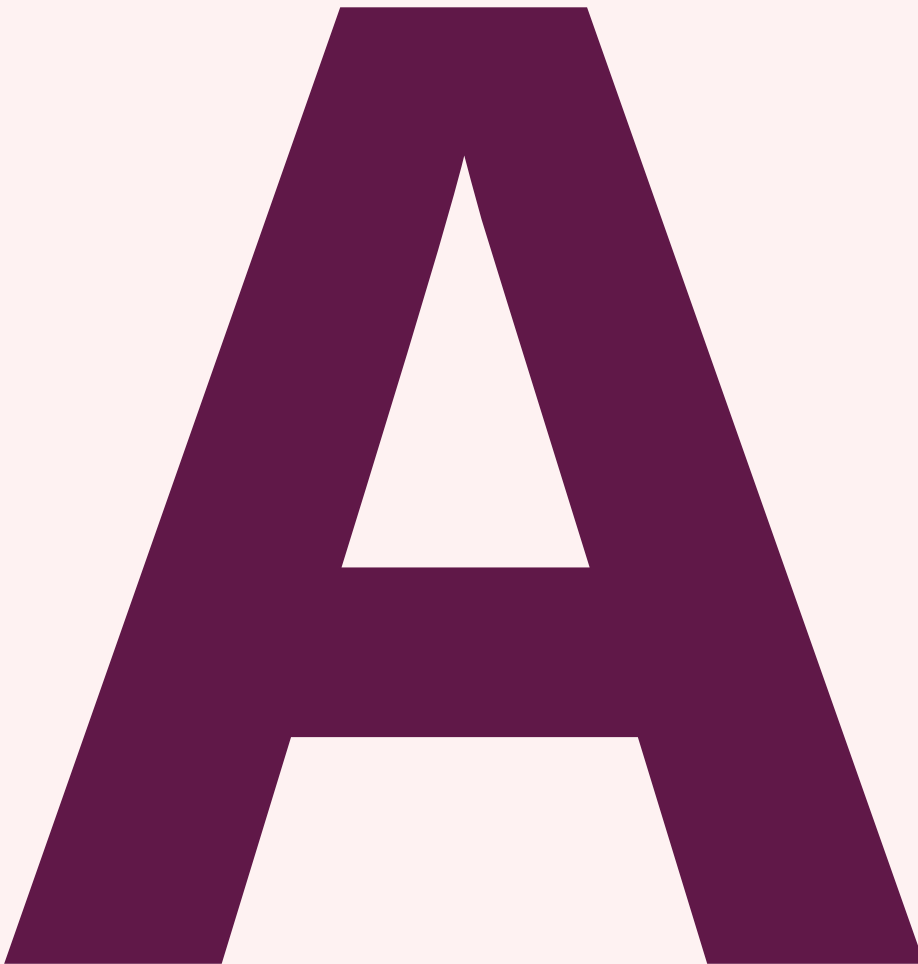
In summary, while *household-level models* are ready for citywide scale-up with limited support from household level, *bulk-generator systems* will require coordinated institutional, technical, and financial interventions to achieve sustainable replication across the state.

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Annexures

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Annexure 1: Summary of Field Observations and Recommendations

A summary of observations and recommendations for the 11 containments surveyed have been provided.

Table A1.1: Field Observations		
Design Details	Observations	Recommendations
Distance of containment system from the building	Most of the tanks are located close to the building	Move the containment as far as possible from the building
Containment system design		
Length	Most of the units conform to recommendations	≥1.5 m (diameter ≥1.35 m for circular tanks)
Width	Most of the units conform to recommendations	≥0.75 m
L/W	<ul style="list-style-type: none"> • Around 25% do not conform to recommendations. • The ratio is less than 2 in all the non-standard cases. 	2 to 4
Effective Depth	Only two containment structures do not follow recommended depth	≥1 m
Volume (cu. m.)	Only one containment structure has a lesser volume	>1 m
HRT (days)	All tanks have a retention time of more than 5 days	2-4 days
Availability of partition wall (numbers)	<ul style="list-style-type: none"> • The majority of tanks (7 out of 11), larger than 2 cu. m., had partition walls. • Tanks wider than 1.2 m did not always include the specified extra partition walls; however, half of them (3 out of 6) had an additional partition wall positioned one-third of the way from the inlet. 	<ul style="list-style-type: none"> • Required tank capacity > 2 cu. m. • When width >1.2 m, additional partition wall at 0.15 m from the inlet, and extending 0.15 m above water level and below invert level to be provided
Level difference between inlet/ outlet	Most of the tanks were built in conformity with standards	Outlet must be 0.05 m below the inlet
Containment construction specification		

Table A1.1: Field Observations

Design Details	Observations	Recommendations
Side wall	All the tanks had a brick lining	<ul style="list-style-type: none"> • Must be of such thickness to provide strength and water tightness <ul style="list-style-type: none"> ○ Brick walls - >0.2 m thick ○ M-Stone walls - 0.37 m thick
Floor		M 15 concrete
Sidewall plastering	Only tanks interiors were plastered	Min. plaster thickness of 12 mm - inside and outside
Position and size of the opening		<ul style="list-style-type: none"> • 0.3 m below the top water level • Rectangular or circular - min. diameter 100 mm and max. diameter 150 mm
Availability of T-pipe	<ul style="list-style-type: none"> • Only 2 tanks had T-pipes. • Both these tanks had a width >1.2 m, but only one T-pipe. 	<ul style="list-style-type: none"> • The top limb rises above scum level, and the bottom limb extends 0.3 m below the top water level. • For tanks <1.2 m wide, one T-shaped dip pipe is to be provided. • For tanks >1.2 m wide, two or more submerged inlets are preferable. • Invert of the bent channel should be 58 mm above top water level.
Free board		≥0.3 m
Vent pipe		<ul style="list-style-type: none"> • Diameter ≥0.05m • Mosquito proofing • Height <ul style="list-style-type: none"> ○ >2 m when nearest building is >20 m away ○ 2 m more than the height of the nearest building
Manhole availability	Most tanks did not have manholes	<ul style="list-style-type: none"> • Each chamber should have a manhole. • A minimum size of 0.455 m x 0.610 m or 0.5 m diameter RCC or cast-iron manhole can be provided. • A suitable lifting device should be available.
Manhole location	None of the tanks have more than one manhole	To be provided for each chamber
Slope at base		1:10 minimum

Table A1.1: Field Observations

Design Details	Observations	Recommendations
Outlet	In most containments, Ductile Iron Pipe (DIP) pipe, also known as T-pipe, at outlet were not present.	<ul style="list-style-type: none"> • For tanks with final outlet less than 1200 mm wide, <ul style="list-style-type: none"> ○ 100 mm nominal bore DIP pipe should be fixed inside the tank with top limb rising above scum level and bottom limb extending to about 1/3rd of the liquid depth below top water level. ○ Invert of the outlet pipe shall be 50 mm below the invert of the inlet pipe. • For tanks with $W > 1.2$ m, weir outlet is to be provided.
Maintenance practice		
Last de-sludging done (in years)	Many of the tanks were de-sludged at an interval of 2-3 years	<ul style="list-style-type: none"> • Half yearly de-sludging is desirable • At least once in 2 years is required
Type of de-sludging equipment used	Vacuum pump fitted tanker lorries	
Maintenance activities related to structure	Maintenance was not carried out since majority of the tanks were under construction	
Disposal system		
Type of disposal system	Half of the systems had soak pits	Soak pit, Trenching
Size of the disposal	Generally, 1 m diameter circular pits	
Length	All soak pits conform to standards	Minimum cross-sectional length of 0.9 m
Width		
Depth		≥1 m
Type of filter material		Brick bats or gravel
Proximity to the surface water		>18 m from any source of drinking water
Proximity to the ground water	Half of the soak pits were located at a distance <18 m to groundwater	>18 m from any source of drinking water
Disposal construction specification		

Table A1.1: Field Observations

Design Details	Observations	Recommendations
Side wall		<ul style="list-style-type: none">• Stone, brick or concrete block lining with dry open joints backed with at least 75 mm of clean coarse aggregate.• Lining above inlet level must be finished with mortar.• If no lining is provided, the entire pit must be filled with loose stone. Masonry ring may be constructed at the top of the ring.

Annexure 2: Sampling and Testing Protocol

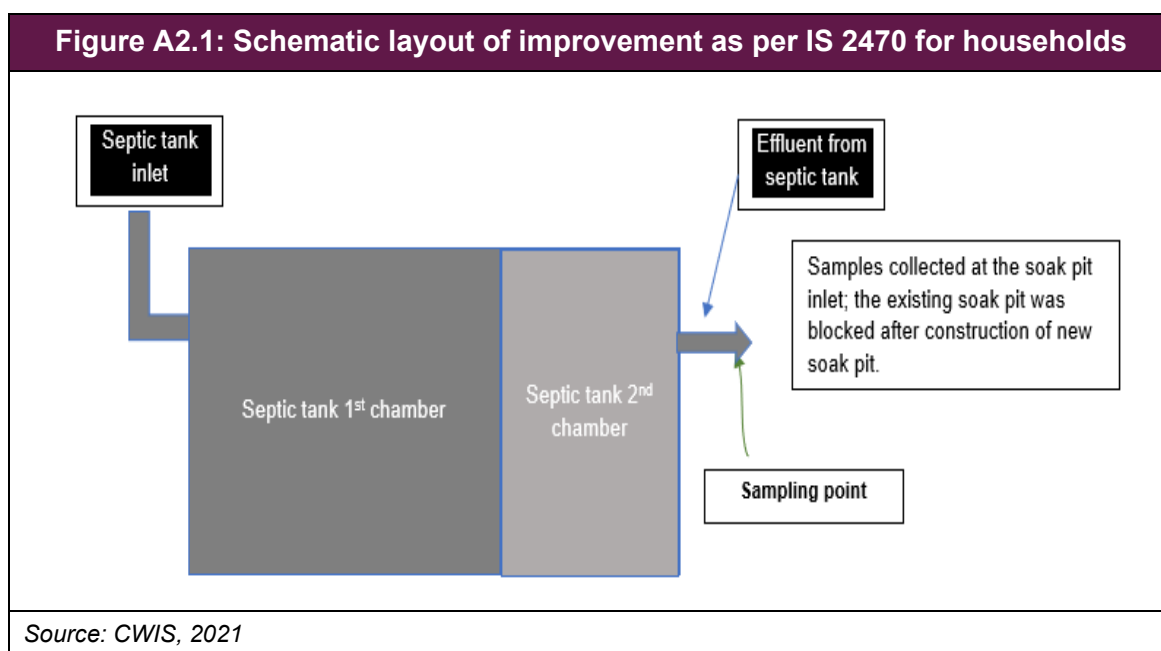
A2.1 Improvement as per IS 2470 for households

A2.1.1 Background

The house was in Srirangam, Trichy with eight members. When the tank filled and overflowed, the wastewater flowed into the open drain by gravity due to an increase in blackwater inflow when in use.

A2.1.2 Containment improvement

The containment was as per IS 2470 with provisions of baffle wall openings at the top, T pipes, slope at the bottom, and vent pipes. The raising of the side wall was also done as per the recommendations. The schematic layout of the improvement is depicted in Figure A2.1 below.

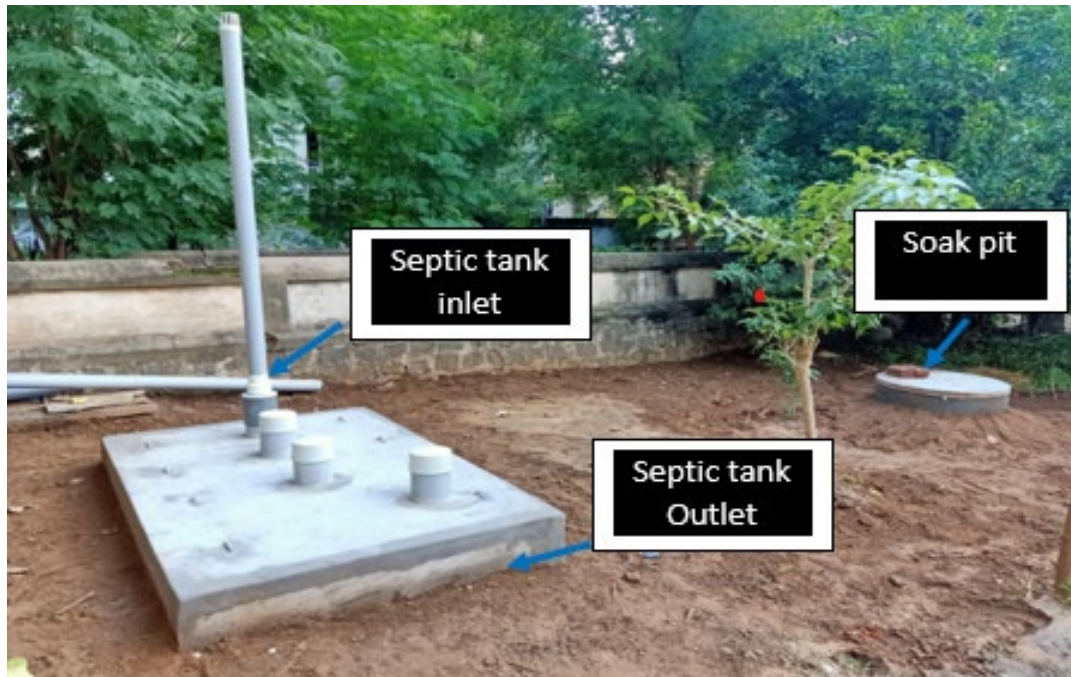


A2.1.3 Proposed samples and sampling points

S. No.	Samples	Sampling Point	Remarks
1	Septic tank	Via Manhole/ Side End Cap	Before contact with Soak pit
2	Soak pit	Via Manhole/ Side End Cap	Soak pit
3	Septic Tank Supernatant	Via Air Vent	Top portion

The analytical parameters (refer section 2.3.3) were measured by transporting 2-litre bottles of liquid on ice to the lab.

Figure A2.2: Sampling points for improved septic tank



Source: CWIS, 2022

A2.1.4 Materials Required

- Pump
- Extension Box
- L Container
- Sludge Judge Sampler
- Gloves
- Mask
- Apron
- Goggles
- Autoclaved bottles (2 L)
- Ethanol
- Parafilm tape
- Ice cubes
- Secondary Container

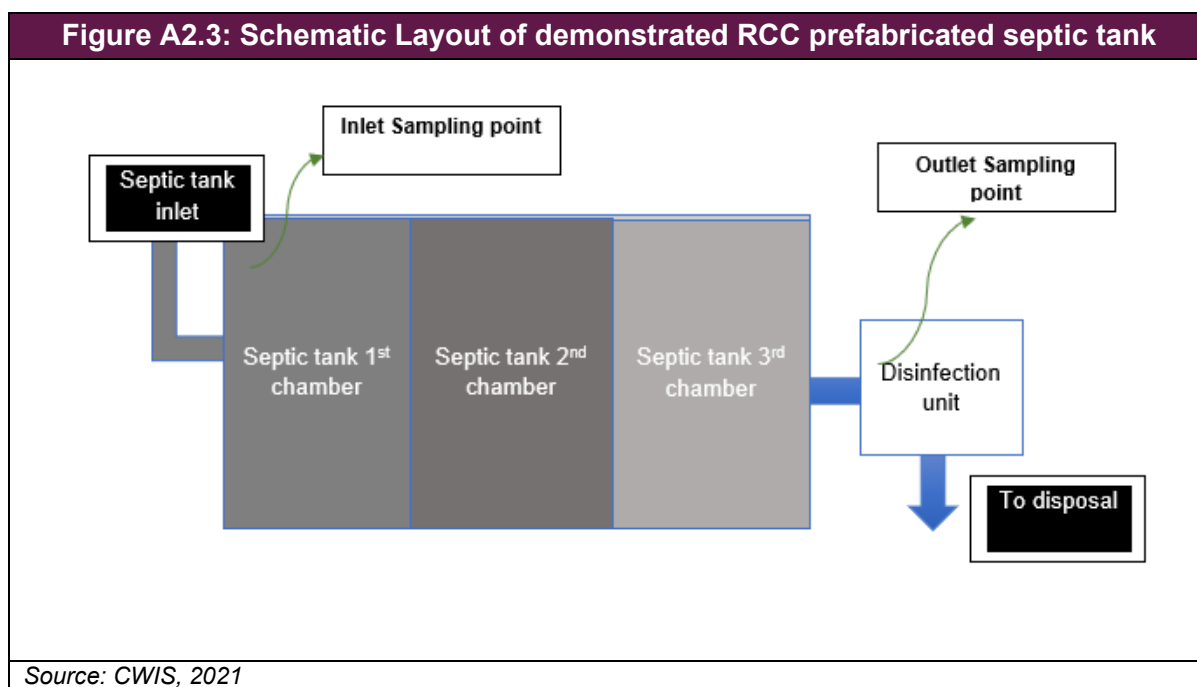
A2.2 Demonstration of RCC prefabricated septic tank

A2.2.1 Background

The household selected for this improvement was at Kodappu, Trichy. Based upon the site assessment, a sampling plan to assess the demonstration of the RCC prefabricated septic tank was developed.

A2.2.2 Containment improvement

The prefabricated septic tank is a circular pipe made of RCC NP3 grade. Two partition walls at an equal interval of 0.83 m are present. The outlet from the toilet is connected to the inlet provision of the tank, allowing sludge to settle at the bottom and treated water is allowed to flow into the outlet chamber to the open drain by gravity. To improve effluent quality by disinfecting pathogenic organisms, an electro-chlorinator was installed in the outlet chamber. The schematic layout of the improvement is depicted in Figure A2.3 below.



A2.2.3 Proposed samples and sampling points

Sl. No	Samples	Sampling Point	Remarks
1	RCC prefabricated septic tank	Via Manhole/ Side End Cap	Before Disinfection chamber
2	Electro-chlorinator disinfection unit	Electro-chlorinator disinfection contact chamber	After Electro-chlorinator disinfection chamber
3	Septic Tank Supernatant	Via Air Vent	Top Portion of Liquid

The analytical parameters (refer section 2.3.3) were measured by transporting 2-litre bottles of liquid on ice to lab.

Figure A2.4: Sampling Points for RCC prefabricated septic tank



Source: CWIS, 2022

A2.2.4 Materials Required

- Pump
- Extension Box
- L Container
- Sludge Judge Sampler
- Gloves
- Mask
- Apron
- Goggles
- Autoclaved bottles (2 L)
- Ethanol
- Parafilm tape
- Ice cubes
- Secondary Container

A2.3 Earthworm Bioreactor

A2.3.1 Background

EBR uses epigeic earthworms in treating the sewage through aerobic decomposition. The existing containments were in damaged condition with broken top slabs and improper disposal arrangements.

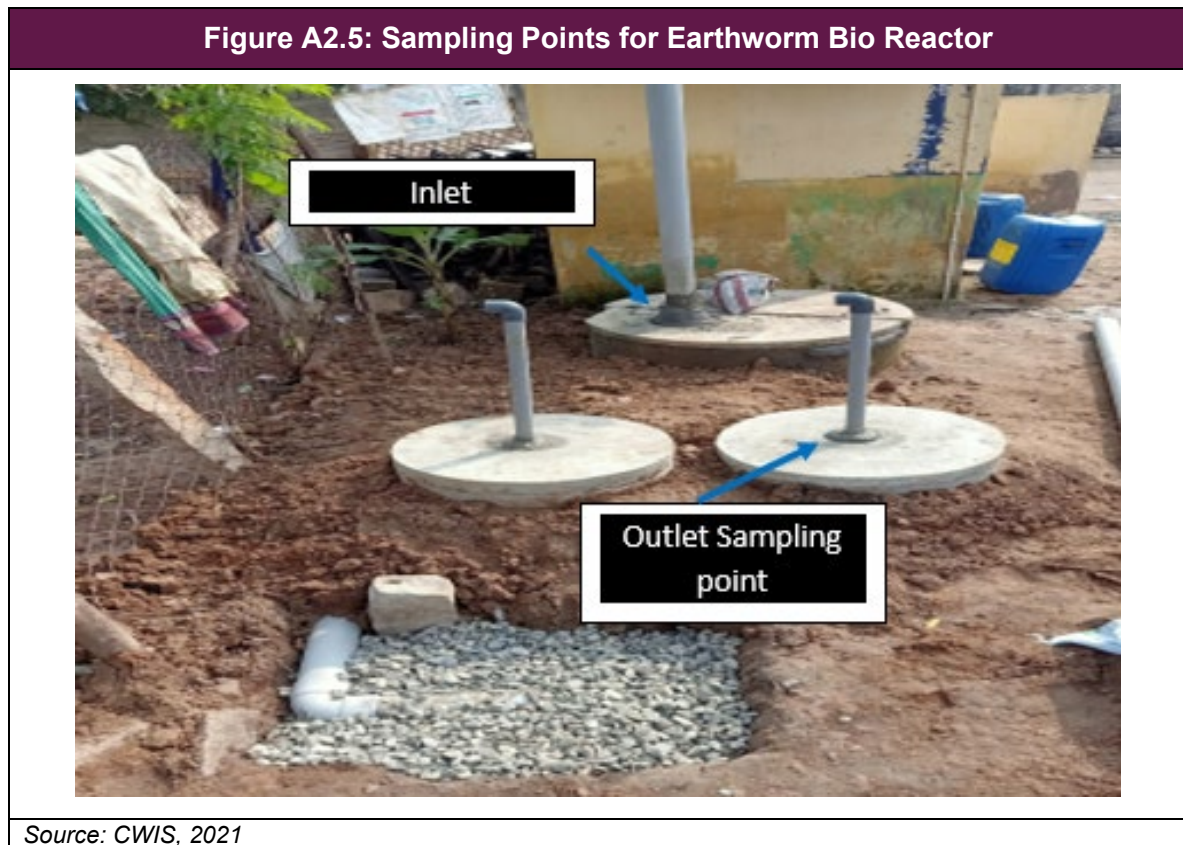
A2.3.2 Containment improvement

The improvement for EBR consists of a 200-litre barrel (with diameter lesser than the digester's inner size) supported on RCC rings at the bottom. With holes at the bottom for drain, the barrel is filled with 200 to 300 mm layer of coco peat with selected earthworms and a net to prevent their escape is provided.

A2.3.3 Proposed samples and sampling points

Table A2.3: Samples and Sampling Points for Earthworm Bio Reactor			
S. No	Samples	Sampling Point	Remarks
1	Septic tank	Via Manhole/ Side End Cap	Before contact with Soak pit

The analytical parameters (refer section 2.3.3) were measured by transporting 2-litre bottles of liquid on ice to lab.



A2.3.4 Materials Required

- Sampler
- Extension Box
- L Container
- Sludge Judge Sampler
- Gloves
- Mask
- Apron
- Goggles
- Autoclaved bottles (2 L)
- Ethanol
- Parafilm tape
- Ice cubes
- Secondary Container

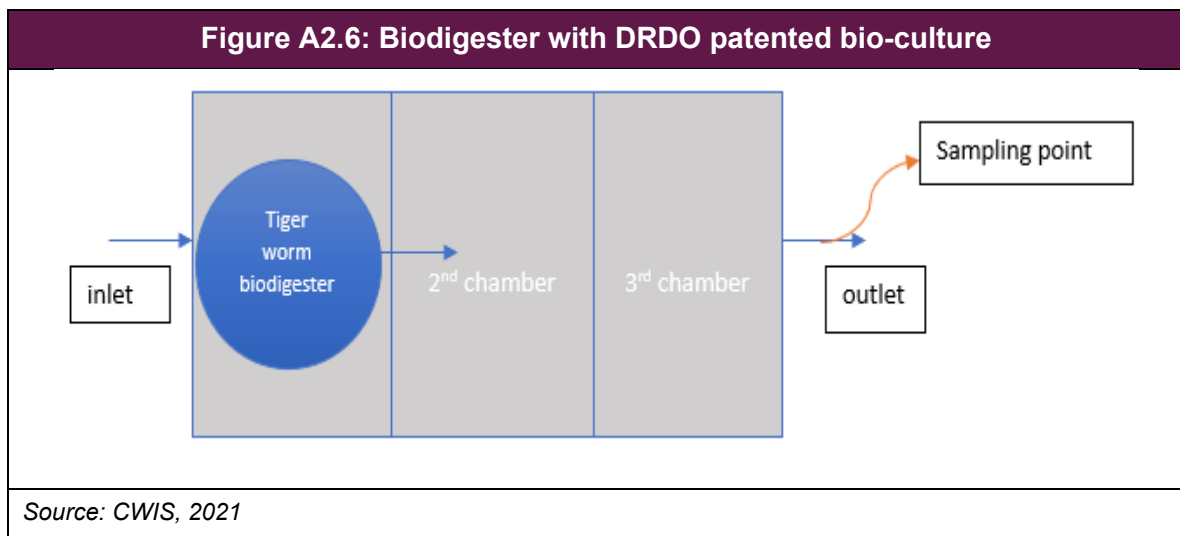
A2.4 Biodigester with DRDO patented bio-culture

A2.4.1 Background

Three different containments were selected for the implementation, of which two located at Karumandabam and the third was in Keela Panjapur. The containments were damaged with leaking walls and no proper disposal arrangement.

A2.4.2 Containment improvement

The digester was placed inside the prepared containment unit at the three sites. The schematic representation of DRDO biodigester is depicted in Figure A2.6.



A2.4.3 Proposed samples and sampling points

Table A2.4: Samples and Sampling Points for DRDO Biodigester			
S. No	Samples	Sampling Point	Remarks
1	Bio Digester	Via Manhole/ Side End Cap	Before contact with Soak pit

The analytical parameters (refer section 2.3.3) were measured by transporting 2-litre bottles of liquid on ice to lab.

Figure A2.7: Sampling Points for DRDO Biodigester



Source: CWIS, 2022

A2.4.4 Materials Required

- Sampler
- Extension Box
- 10 L Container
- Sludge Judge Sampler
- Gloves
- Mask
- Apron
- Goggles
- Autoclaved bottles (2 L)
- Ethanol
- Parafilm tape
- Ice cubes
- Secondary Container

A2.5 Effluent treatment using Chlorine Tablet System

A2.5.1 Background

The containment improvement site was in Kodappu, an urban poor settlement requiring sanitation improvement.

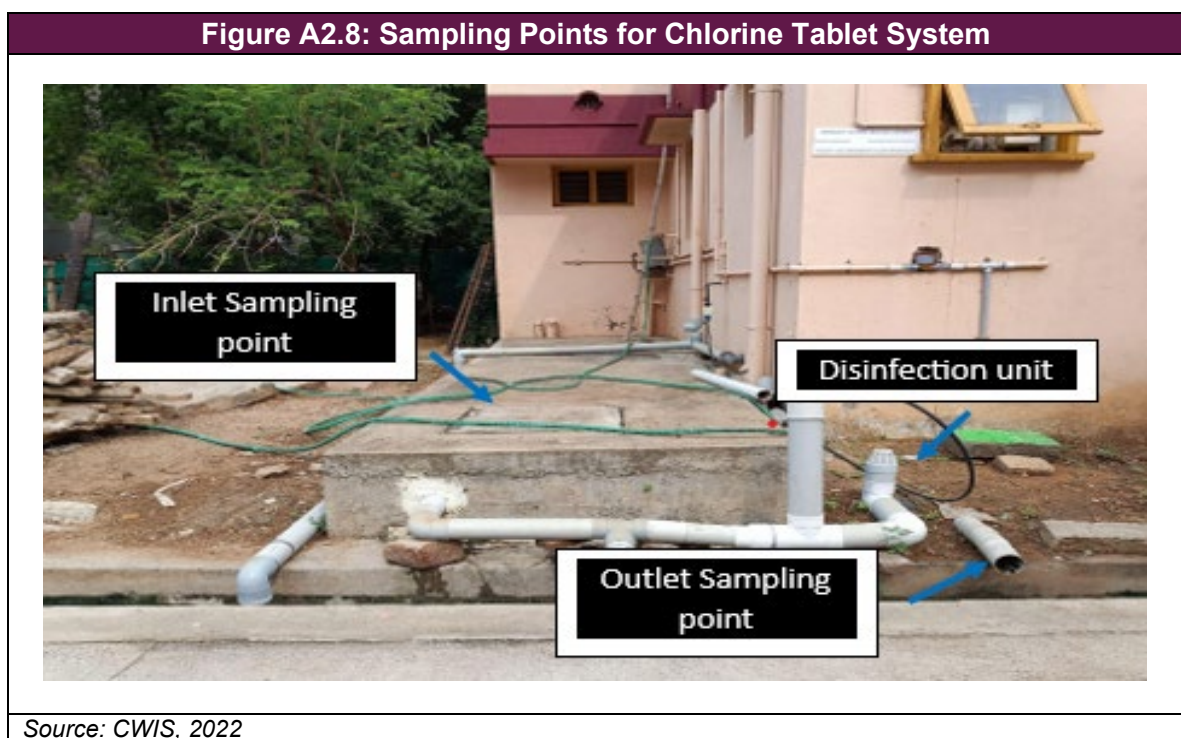
A2.5.2 Chlorine contact tank

The effluent from septic tank (overflow from the filled septic tank) comes in contact with the chlorine solution (made with passing tap water for 5 seconds to 200 g of chlorine tablets) at regular intervals and the chlorine-dosed effluent is stored in chlorine contact tank and over-flows to the open drain.

A2.5.3 Proposed samples and sampling points

Table A2.5: Samples and Sampling Points for Chlorine Tablet System			
S. No	Samples	Sampling Point	Remarks
1	Septic Tank Supernatant	Via Manhole/Side End Cap	Before Disinfection
2	Effluent Dosed with Chlorine	Chlorine Contact Tank	After Disinfection

The analytical parameters (refer section 2.3.3) were measured by transporting 2-litre bottles of liquid on ice to the lab.



A2.5.4 Material Required

- Pump
- Extension Box
- L Container
- Sludge Judge Sampler
- Gloves
- Mask
- Apron
- Goggles
- Autoclaved bottles (2 L)

- Ethanol
- Parafilm tape
- Ice cubes
- Secondary Container

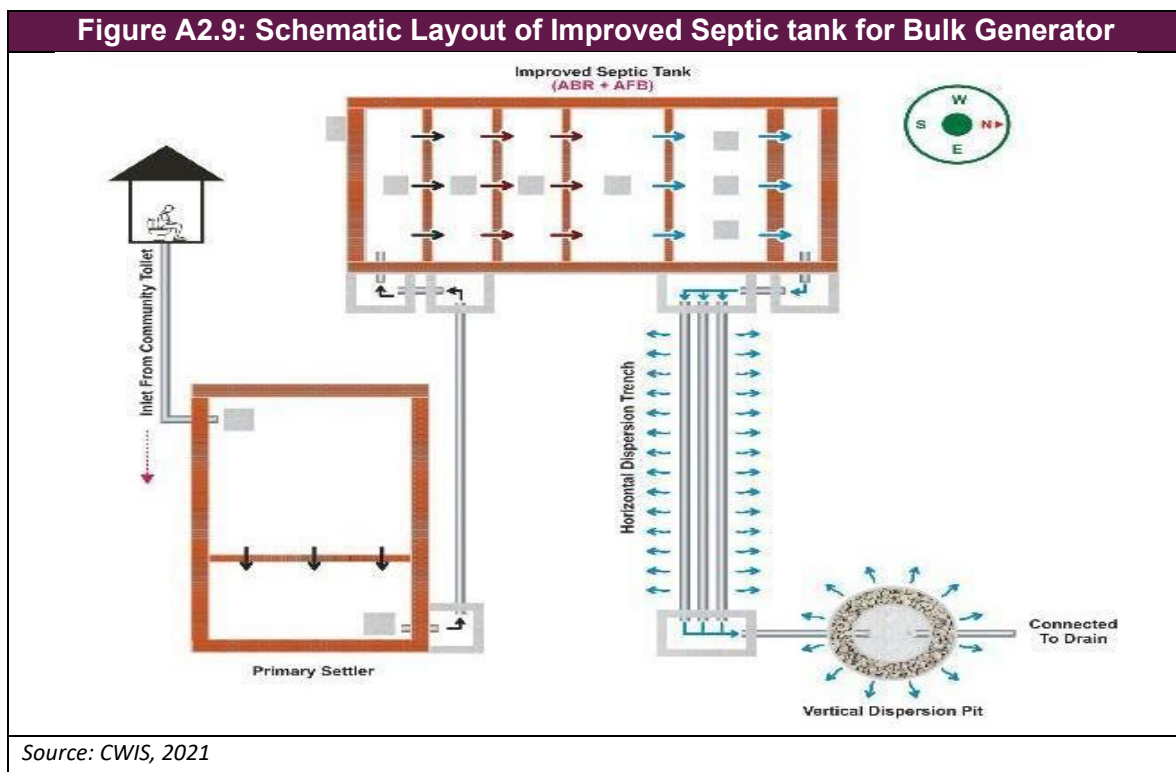
A2.6 Improved Septic Tank for Bulk Generator

A2.6.1 Background

An improved septic tank was demonstrated at a community toilet located at RMS colony, Anna Nagar (Edamalapattiputhur). The toilet had high rate of de-sludging due to improper disposal system, and was frequently closed to de-sludge the septic tank.

A2.6.2 Containment improvement

The improved septic tank has baffle walls and anaerobic filters based on the site-specific requirement. These initiatives will reduce de-sludging frequency, improve treatment efficiency and reduce the contamination around the area. Figure A2.10 depicts the schematic layout of the improved septic tank for bulk generator.

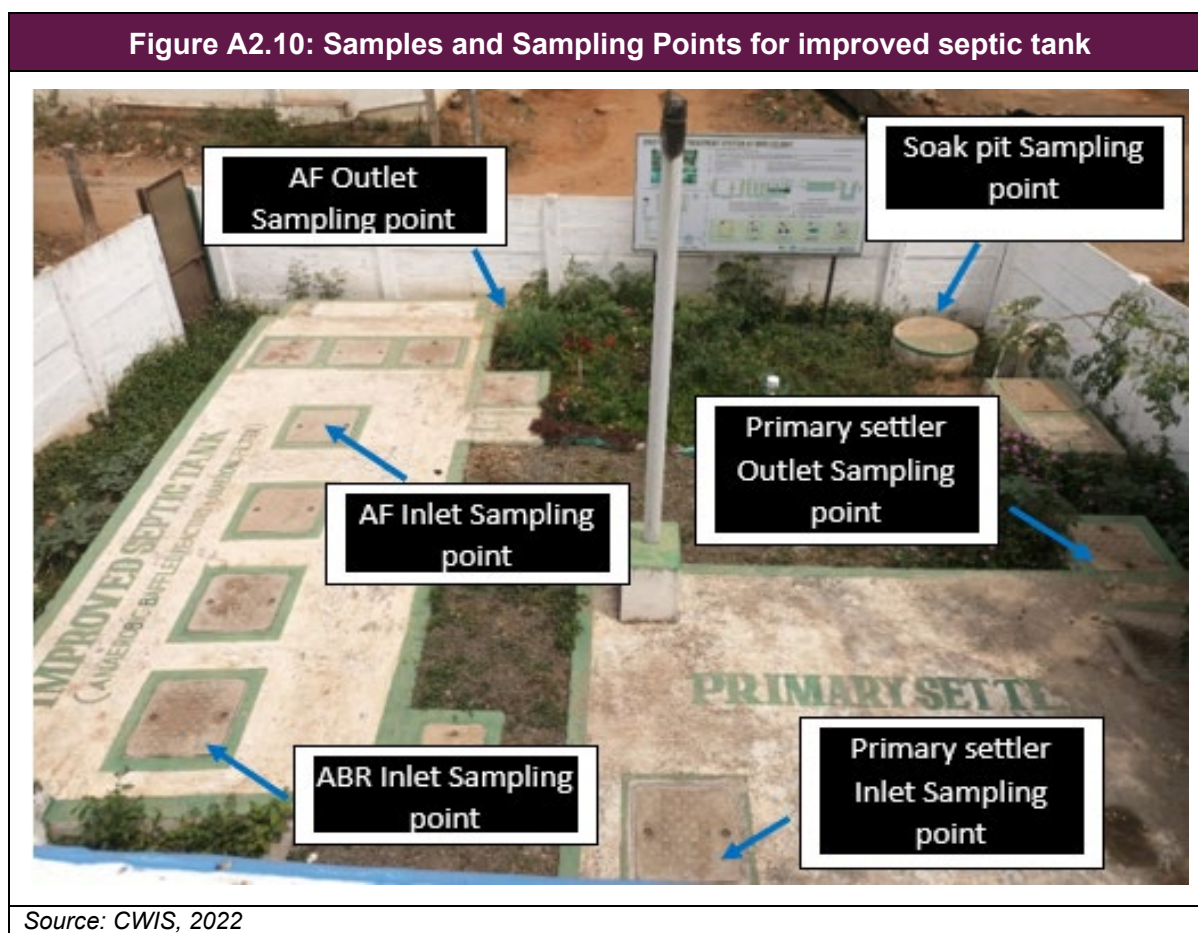


A2.6.3 Proposed samples and sampling points

Table A2.6: Samples and Sampling Points for improved septic tank			
S. No	Samples	Sampling Point	Remarks
1	Septic Tank Supernatant	Via Manhole/Side End Cap	Before Disinfection
2	Septic Tank Supernatant	Via Manhole/Side End Cap	Before Disinfection

Table A2.6: Samples and Sampling Points for improved septic tank			
S. No	Samples	Sampling Point	Remarks
3	Improved Septic tank	Via Manhole/Side End Cap	Before Disinfection
4	Improved Septic tank	Via Manhole/Side End Cap	Before Disinfection
5	Improved Septic tank	Via Manhole/Side End Cap	Before Disinfection
6	Soak pit	Via Manhole/Side End Cap	After Disinfection

The analytical parameters (refer section 2.3.3) were measured by transporting 2-litre bottles of liquid on ice to lab.



A2.6.4 Material Required

- Pump
- Extension Box
- 10 L Container
- Sludge Judge Sampler
- Gloves
- Mask
- Apron

- Goggles
- Autoclaved bottles (2 L)
- Ethanol
- Parafilm tape
- Ice cubes
- Secondary Container

A2.7 Earthworm-based Bioreactor with Digester

A2.7.1 Background

The site for implementing EBR selected was the containment of the Thulasinganagar CT, serving a community 60 to 70 users per day, on the banks of the Koraiyar River channel. The existing containment was not completely damaged but required better disposal system.

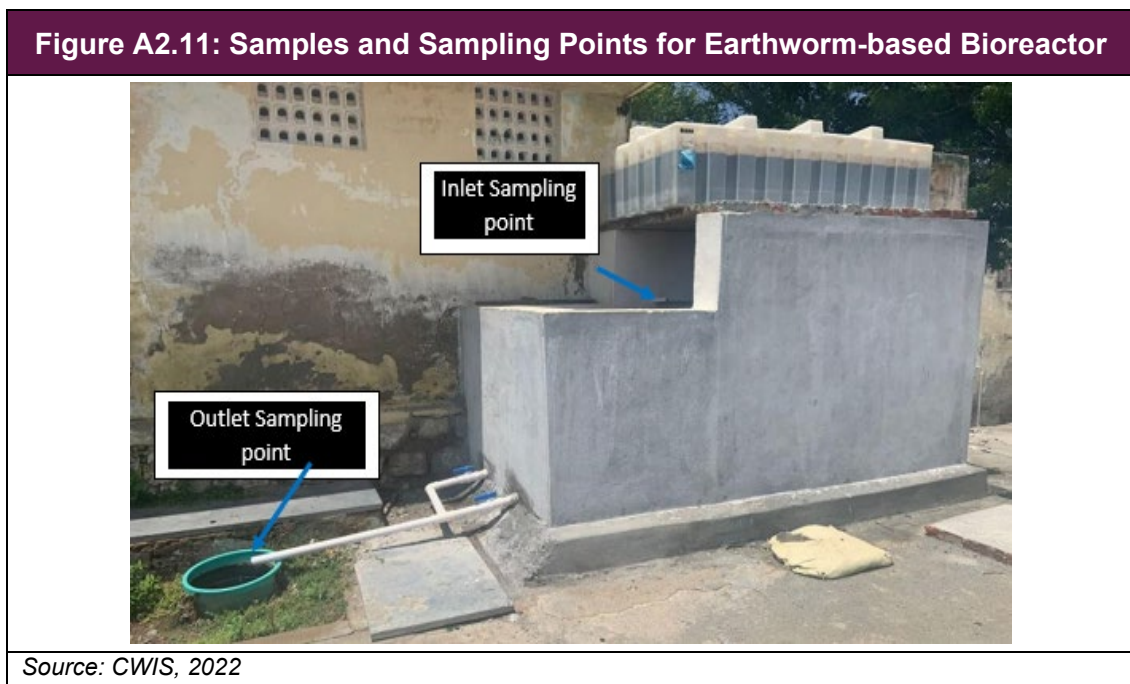
A2.7.2 EBR setup

The biofilter unit consists of a bed of earthworms and bacteria. When wastewater from the primary settler is pumped into the biofilter unit, earthworms will consume the trapped organic matter and the bacteria form biofilms to remove the organic material.

A2.7.3 Proposed samples and sampling points

Table A2.7: Samples and Sampling Points for Earthworm Bio Reactor			
S. No.	Samples	Sampling Point	Remarks
1	Septic Tank Supernatant	Pipeline	Before Disinfection
2	Septic Tank Supernatant	Pipeline	Before Disinfection

The analytical parameters (refer section 2.3.3) were measured by transporting 2-litre bottles of liquid on ice to lab.



A2.7.4 Material Required

- Pump
- Extension Box
- L Container
- Sludge Judge Sampler
- Gloves
- Mask
- Apron
- Goggles
- Autoclaved bottles (2 L)
- Ethanol
- Parafilm tape
- Ice cubes
- Secondary Container

Annexure 3: IHHL Containment Improvement Questionnaires

A3.1 Household questionnaire

Zone/ Ward number					
Location of the toilet					
Geo graphical location:	Latitude		Longitude		Level(m) apx
Total no of users					
Source of water supply					
Water supply qty					
Type of flushing	<input type="checkbox"/>	Cistern type	<input type="checkbox"/>	Pour type	<input type="checkbox"/> Both
Containment					
Type of containment	<input type="checkbox"/>	Septic Tank (ST)			
	<input type="checkbox"/>	Holding Tank (HT)			
	<input type="checkbox"/>	Single pit			
	<input type="checkbox"/>	Twin pit			
	<input type="checkbox"/>	Other type (Describe)			
	<input type="checkbox"/>	No system / Direct discharge			
Construction type					
Side wall	Brick	Concrete	Other		
Bottom	Brick	Concrete	Other		
Top	In-situ	Precast	Other		
Notes					

Containment system size	Dia	L	B	D (Ovr)	D (Eff)
L/B ratio					
HRT					
SRT					
Availability of partition wall					
Number of openings in Partition wall					
Position and size of opening					
Availability of T-pipe	Inlet			Outlet	
Free board					
Vent pipe	Available			Not available	
Inlet to outlet diff in level					
Manhole availability (Access for O&M)	YES			NO	
Manhole location	Inlet		Outlet		Partition wall
Access description					
Plastering	Inside plastered		Outside plastered		
The slope at the base	Provided or not provided				
Proximity to the surface water					
Proximity to the ground water					
Cost of containment					
Cost of plumbing					
Outlet mechanism to discharge supernatant					
Disposal system					

Type of disposal system	<input type="checkbox"/>	Soak pit			
	<input type="checkbox"/>	Dispersion trench			
	<input type="checkbox"/>	Direct disposal			
	<input type="checkbox"/>	Secondary treatment			
	<input type="checkbox"/>	Others (Specify)			
Size of the disposal	Dia	L	B	D (Ovr)	D (Eff)
Type of construction					
Side wall	Brick	Concrete		Other	
Base slab	Brick	Concrete		Other	
Top slab	In-situ	Precast		Others	
Notes					
Cost of disposal system					
Cost of plumbing					
Type of filter material used					
Proximity to Containment					
Vent pipe provision					
Access on top					
Proximity to the surface water					
Proximity to the ground water					
O&M					
Cost of de-sludging					
Last de-sludging done					

Type of de-sludging equipment used	Truck	Pump	Manual
Any maintenance carried out - related to containment or disposal system			
Issues related to existing system			
General Information			
Average temperature and rainfall in the area			
Chances of flooding			
Soil Type			
Water percolation capacity of soil			
Back flow observation			
Visible septic waste around the tank? (observation)			
Odour			
Water contamination in the SWD			
Water contamination in the water source			
Mosquito breeding			
General Notes			

A3.2 Engineers/Mason questionnaire

Name		
Profession		
Design basis for containment	IS Code	If local practice, specify (a-g)

Sizing w.r.t. To user/ land availability		
Partition wall		
Inlet/ outlet T-pipe		
Manhole		
Vent pipe		
Plastering		
De-sludging frequency		
Design basis for disposal system		
Sizing w.r.t. To user/ land availability		
Filter media used		
Inlet pipe mechanism		
Manhole		
Vent pipe		
De-sludging frequency if carried out		
Any overflow arrangement, if provided		
Approval Obtained from authority	No	If yes, specify
Construction specification for containment system (specify the practice)		
Construction specification for disposal system (specify the practice)		
Cost consideration for containment system		

Cost consideration for disposal system	
Issues faced/ Recommendations by the designer (on design and construction)	
Suggestions on improvements required in design and implementation practice	

A3.3 DSO Questionnaire

Date: DD MM YYYY		Format No: IIHS/DSO/01 – R0	
Name of the Service provider			
Number of vehicles			
Type of de-sludging system	Vacuum <input type="checkbox"/>	Pumping <input type="checkbox"/>	Others (Specify)
Sludge storage capacity (L)			
Average number of de-sludging carried per day			
Location of disposal			
Cost of de-sludging for different capacities			
De-sludging method (Give complete note on entire process)			
Issues faced by the operator in desludging containment systems	Yes (If yes, specify as per 8: a-c)	No	
Location access			
Tank access			
Sucking of sludge (thick, grit etc.)			

Issues faced by the operator in desludging disposal systems (if carried out)	Location access Tank access Sucking of sludge (thick, grit etc.)
Location access	
Tank access	
Sucking of sludge (thick, grit etc.)	
Suggestions on improvements required in design and construction of containment and disposal system	

Place:

Surveyed By:

Annexure 4: Predominant Technologies for containment improvement

Sl. No.	Agency name	Technology
DRDO-patented Biodigester setups		
1	Life plus	Improved septic tank with microbial inoculum
2	Elefo Biotech	DRDO Biodigester
3	Bio man septic tank	DRDO-patented biodigester
4	Pratiks Environmental Solutions, Chennai	Bio septic tanks-a series of soak pits after the septic tank + use of DRDO patented bacteria
5	ABC Ureka - Bio septic tank Coimbatore-641012	DRDO-patented biodigester
6	Mac bio tech	DRDO-patented biodigester
7	Fixed Film bio reactors along with Bio-culture	Fixed Film Bioreactors (FFBR) with bio-culture use fixed media to support microbial biofilms, enhancing wastewater treatment efficiency. This system ensures effective pollutant breakdown with minimal maintenance, making it ideal for decentralised applications.
8	Geo Enviro Solution, Tiruchirappalli - 620018	FRP type bio digester with DRDO patented inoculum
9	CDD (DEWATS) system	Supply and installation of one number of prefabricated Biogas Settler (Preliminary Treatment)
10	S R Energy, Tiruchirappalli, Tamil Nadu 620017	Readymade septic tanks with Bio-digester
Readymade septic tanks with Johkasou system		
11	HECS Daiki, New Delhi-110025	Johkasou
12	Sintex precast tank, Kalol (N.Gujarat) 382 721	Sintex modular septic tanks with Anaerobic reactor
Earthworm-based technology		
13	TBF Environmental solutions Pvt Ltd	Tiger worms suitable for pits
14	Absolute water	Bio STP – Worm-based technology
Mechanical treatment system		
15	Biomicrobics Small scale treatment system	Aeration and introduction of PVC fillers in the second chamber
16	Ecosbr Compact for Individual Home STP, Chennai 603 112, India	Ecosbr plants operate as sequence batch reactors
17	W&WW Technologies	KLARO-SBR

Physical improvement		
18	Biorock septic tanks	Bio rock used as a media before disposal
19	United Sanitation Devices, Kerala, India - 680 555	Prefabricated RCC pipes septic tanks
20	VME Precast Private Limited, Kanchipuram - 602105, Tamil Nadu	Prefabricated RCC septic tanks (Rectangular in size)

Annexure 5: Cost Estimates for the Demonstrations

A5.1 IS 2470 Containment improvement renovation work

Sl. No.	Description of Work	Unit	Qty	Rate	Amount
Septic Tank (A)					
1	Cement concrete 1:5:10 (one cement, five sand, and ten hard broken stone jelly) using 40 mm gauge hard broken granite stone jelly for foundation including dewatering wherever necessary and laid in layers of not more than 15 cm thick well rammed, consolidated, and curing, etc.,	Cubic metre	0.43	3,706.00	1,594.00
2	Cement concrete 1:1-1/2:3 (one cement, one and a half sand, and three hard broken stone jelly) using 20 mm gauge hard broken granite stone jelly for all RCC items of works excluding cost of reinforcement grill and fabricating charges shuttering but including laying, vibrating with mechanical vibrators, finishing, curing, etc.	Cubic metre	0.25	7,603.91	1,901.00
3	Brick work in cement mortar 1:5 using best quality of country bricks of size 8-3/4" x 4-1/4" x 2-1/4" including curing, etc.,	Cubic metre	1.08	4,758.30	5,139.00
4	Brick partition walls of 11.50 cm thickness using best quality II Class table-moulded chamber-burnt bricks of size 9" x 4-1/2" x 3" in cement mortar 1:3 (one cement and three sand) using hoop iron reinforcement if found necessary including curing etc.	Square metre	0.5	765.05	383.00
5	Plastering with cement mortar 1:5 (one cement and five sand), 12 mm thick in all floors including curing etc. complete complying with standard specification as instructed or directed by the engineering in charge	Square metre	13.00	349.85	4,548.00
6	Supplying and fixing in position best quality PVC soil / waste pipes of various dia having 6 kg / sq.cm. Pressure BIS mark and providing leak proof joints using PVC adhesives including fixing to the wall with special PVC / MS clamp, teak wood plugs, brass screws, etc.				

Sl. No.	Description of Work	Unit	Qty	Rate	Amount
	110 mm dia PVC pipe	Running metre	4.90	250.00	1,225.00
	110 mm dia Tee	Numbers	2.00	110.00	220.00
7	Supplying, fabricating, and placing in position Ribbed Tor Steel grills for all RCC works as per design given including cost of steel and G.I. binding wire in all floors etc.	Kilogram	13.00	104.00	1,358.00
Total (A)					16,368.00
Soak Pit (B)					
8	Cement concrete 1:1-1/2:3 (one cement, one and a half sand and three hard broken stone jelly) using 20 mm gauge hard broken granite stone jelly for all RCC items of works excluding cost of reinforcement grill and fabricating charges shuttering but including laying, vibrating with mechanical vibrators, finishing, curing, etc.	Cubic metre	0.08	7,603.91	608.00
9	Supplying and fixing in position of RCC ring well of 4' ring well with 1' height using cement mortar slush including lifting and fixing in position with proper gradient etc., complete complying as per standard specification as instructed or directed by the engineering in charge.	Numbers	4.00	600.00	2,400.00
10	Providing and supplying hard broken 40 mm aggregate filling the pit with filling in foundation and basement including labour charges etc., completely complying with standard specification as instructed or directed by the engineering charges	Cubic metre	0.50	980.00	490.00
11	Supplying and fixing in a position best quality PVC soil/waste pipes of various dia having 6 kg / sq.cm. Pressure BIS mark and providing leak proof joints using PVC adhesives including fixing to the wall with special PVC / MS clamp, teak wood plugs, brass screws, etc.,				
	110 mm dia PVC pipe	Running metre	2.00	250.00	500.00
12	Supplying PVC Specials (with working pressure 10 kg. / sq.cm.) In water supply arrangements (both internal and external water supply arrangements etc, approved as instructed or directed by the engineer in charge.				

Sl. No.	Description of Work	Unit	Qty	Rate	Amount
	110mm dia Elbow	Numbers	1.00	110.00	110.00
13	Supply and laying of blue metal of sizes from 40 to 100 mm for the bottom layer and side filler for the soak pit.	Cubic metre	0.5	3,600.00	1,800.00
Total (B)					5,908.00
14	Labour cost				
	Labour costs for the civil and plumbing works				
	Mason	Resource days	4	1,050.00	4,200.00
	Helper - Skilled	Resource days	8	850.00	6,800.00
	Helper - unskilled	Resource days	9	700.00	6,300.00
	Plumber and Helper	Resource days	1	900.00	900.00
	Centring and bar bending	Resource days	1	900.00	900.00
Total (C)					19,100.00
TOTAL (A+B+C)					41,376.00
15	OpEx cost				
	De-sludging cost whenever required (consider once in two years)	Trips/ annum	0.5	2,500.00	1,250.00
Total (CapEx)/ annum					1,250.00
Note:					
1.	The provided amount is tentative only, based on the site conditions and assumptions actual cost may vary. This shall be used for the reference purpose only. For tendering and contract, separate actual Bill of Quantity (BOQ) shall be prepared based on the ULBs requirement and site conditions.				
2.	The cost provided here is based on the market inquiry and Public Works Department (PWD) Schedule of Rates (SOR) reference				
3.	GST and other taxes are not considered for the estimation.				
4.	Based on the quantum of the work the rates will be reduced further; presently it is considered for installation of a single unit.				

A5.1.1 Financials

Initial installation cost	The expenses made during the improvement as per IS 2470 for initial installation or renovation are between INR 25,000 and INR 42,000 for 5 users containment system with soak pit. So, minimum of INR 25,000 and maximum of INR 42,000 are considered as contributing to the life cycle cost analysis.
Operating costs	<p>This includes the cost of de-sludging the tank for once in every 2 years. The market rate at Trichy is INR 2,500 for every trip, based on the following assumptions:</p> <ul style="list-style-type: none"> • Removal of blockages in the feeder line to the septic tank • Not more than 3 lengths of the pipe joint during de-sludging • Not more than 10 km (distance on road) between collection and disposal points
Replacement cost	<p>This includes the cost of repairing or replacing or reconstructing the septic tank after its 15-year lifespan. Considering the same minimum cost incurred during the improvement of INR 25,000 to improve the structure as per the site conditions, the total life cycle cost for the improvement as per IS 2470 recommendation is,</p> <ul style="list-style-type: none"> • Min – 25,000 + (2,500 x 7 [7 times in 15 years]) + 25,000 = 67,500 ~ INR 68,000. • Max – 42,000 + (2,500 x 7 [7 times in 15 years]) + 25,000 = 84,500 ~ INR 85,000

A5.2 DRDO-patented Biodigester with PVC drum setup

(Containment improvement model for the pits)



DRDO patented Biodigester septic tank with soak pit					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
Biodigester & Soak Pit – CAPEX					
1	Locally manufactured DRDO patented biodigester septic tank (900 mm dia & 900 mm depth) with 100 thick cover slabs, including transportation charges, etc.,	Numbers	1.00	5,000.00	5,000.00
2	RCC ring 4' cover slab lifting and fixing in position with proper gradient etc.,	Numbers	1.00	500.00	500.00
3	Providing and supplying hard broken 40 mm Aggregate filling the pit with filling in the bottom of the soak pit including labour charges etc., completely complying with standard specification as instructed or directed by the engineering charges	Cubic metre	0.39	2,000.00	780.00
4	Supplying and fixing in a position best quality PVC soil/waste pipes of various dia having 6 kg / sq.cm. Pressure BIS mark and providing leak proof joints using PVC adhesives including fixing to the wall with special PVC / SS clamp, teak wood plugs, brass screws, etc.,				
	110 mm dia PVC pipe	Running metre	6.00	250.00	1,500.00
	110mm dia Tee	Numbers	4.00	135.00	540.00
	110mm dia PVC elbow for soak pit	Number	1.00	110.00	110.00
5	Supplying and fixing in position of RCC ring well of 1200 mm with 300 mm height for the soak pit and the joint to be packed using cement mortar plaster. The side walls are to be provided with perforated opens of min 25 mm opens randomly to disperse the water through the sides of the pit.	Numbers	5.00	600.00	3,000.00
Total CapEx					11,430.00
Biodigester & Soak Pit – OpEx					
1	Cost of the de-sludging or addition of inoculum if any.	Once in two years	1	2,000.00	2,000.00
Total OpEx (per annum)					2,000.00

DRDO patented Biodigester septic tank with soak pit					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
	Note:				
1	The provided amount is tentative only, based on the site conditions and assumptions actual cost may vary. This shall be used for the reference purpose only. For tendering and contract, separate actual BOQ shall be prepared based on the ULBs requirement and site conditions.				
2	The cost provided here is based on the market inquiry and PWD SOR reference				
3	GST and other taxes are not considered for the estimation.				

A5.2.1 Financials

Initial installation cost	The costs for biodigester installation and initial operations are INR. 11,430.
Operating costs	This includes the cost of de-sludging provision or bacterium addition whenever required or once in every two years. The cost for single de-sludging is INR 2,000. So, it is considered INR 1,000 for one year. The total life span considered is 15 years = 15 x 1,000 = INR 15,000.
Replacement cost	<p>This includes the cost of repairing or replacing or reconstructing the septic tank after its 15-year lifespan. Including the cost of de-sludging and repairing or rectification of the minor issues in the tank, a lump sum amount of INR 8,000 is considered (consider de-sludging INR 2,000 + cleaning and disinfection 1,000 + Epoxy painting inside the pit INR 5,000), for once in every 15 years.</p> <p>So, total LCC for the improvement as per DRDO patented bio-digester with RCC ring and soak pit model,</p> <ul style="list-style-type: none"> • Min – 11,430 + 15,000 + 8,000 = 34,430 ~ INR 35,000 • Max – 11,430 + 15,000 + 11,430 = 37,860 ~ INR 38,000

A5.3 DRDO-patented Biodigester with Dispersion Pit

(Containment improvement model for the single or twin pits)

Figure A5.2: Reinforced Cement Concrete (RCC) Biodigester



Source: CWIS, 2022

DRDO-patented Biodigester septic tank at Thiruvanaikovil, Trichy

Biodigester & Soak Pit (A)

Sl. No.	Description of Work	Unit	Qty	Rate	Amount
1	DRDO-patented biodigester septic tank (900 mm dia & 600 mm depth) with 100 thick cover slab, including transportation charges, etc.,	Rs	1	10,000.00	10,000.00
2	Cleaning light jungle with necessary materials and labour charges etc., complete complying with standard specification as instructed or directed by the engineering in-charge	M2	20.00	3.90	78.00
3	Ordinary soil SS20B earth work excavating and depositing on bank with initial lead of 10m & initial lift of 2m in sand, silt or other loose soil, wet sand or silt not under water, light black cotton soil, sandy loam and ordinary soil including excavated earth	M3	0.79	48.80	38.55

DRDO-patented Biodigester septic tank at Thiruvanaikovil, Trichy

Biodigester & Soak Pit (A)

Sl. No.	Description of Work	Unit	Qty	Rate	Amount
4	Cement concrete 1:1-1/2:3 (one cement, one and a half sand and three hard broken stone jelly) using 20 mm gauge hard broken granite stone jelly for all RCC items of works excluding cost of reinforcement grill and fabricating charges centring and shuttering but including laying, vibrating with mechanical vibrators, finishing, curing, etc. and providing fixtures like fan clamps in the RCC floor / roof slabs wherever necessary and bearing surfaces of walls, beams etc. shall be finished smooth with Cement Mortar 1:3 (One Cement and Three Sand) and kraft paper laid over it without claiming extra, etc. complete complying with standard specification as instructed or directed by the engineering in-charge	M3	0.08	7,603.91	608.31
5	Supplying and fixing in position of RCC ring well of 4' ring well with 1' height using cement mortar slush including lifting and fixing in position with proper gradient etc., complete complying as per standard specification as instructed or directed by the engineering in charge.		5.00	1,111.00	5,555.00
6	RCC ring 4' cover slab lifting and fixing in position with proper gradient etc.		1.00	900.00	900.00
7	Providing and suppling hard broken 40 mm aggregate filling the pit with filling in foundation and basement including labour charges etc., complete complying with standard specification as instructed or directed by the engineering charges		0.39	980.00	382.20
	Supplying and fixing in position best quality PVC soil / waste pipes of various dia having 6 kg / sq.cm. pressure BIS mark and providing leak proof joints using PVC adhesives including fixing to the wall with special PVC / MS clamp, teak wood plugs, brass screws, etc., and making connection to all sanitary fittings, dismantling masonry / RCC works wherever found necessary and making the good dismantled portion to the original condition, including testing for any leakages, etc., complete complying with standard specifications. (The PVC pipes should be got approved by the as instructed or directed by the engineering in charge). The rate for earth work excavation will be measured and paid separately in the cases where the pipelines are proposed to laid below ground level				0.00

DRDO-patented Biodigester septic tank at Thiruvanaikovil, Trichy					
Biodigester & Soak Pit (A)					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
8	110 mm dia PVC pipe	Rm	3.00	381.40	1144.20
	Supplying PVC Specials (with working pressure 10 kg. / sq.cm.) in water supply arrangements (both in internal and external water supply arrangements etc., approved by the as instructed or directed by the engineering in charge				0.00
9	110mm dia Elbow	Each	3.00	106.60	319.80
	Vent pipe 2.5 m length (2 Nos)	Rmt	2.00	480.00	960.00
10	Refilling with excavated soil (other than sand) complying with standard specification for filling in foundation and basement etc., complete complying with standard specification as instructed or directed by the engineering in charge	M3	10.00	25.50	255.00
Total (A)					19987.00
11	Labour Cost & Maintenance (B)				
	Skilled Labour	Rs	1	1,000.00	1,000.00
	Unskilled Labour	Rs	2	500.00	1,000.00
	Plumber	Rs	1	900.00	900.00
	Helper	Rs	1	700.00	700.00
12	De-sludging cost whenever required	Rs	1	2,000.00	2,000.00
Total (B)					5,600.00

DRDO-patented Biodigester Septic Tank at Thiruvanaikovil, Trichy					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
Biodigester & Soak Pit (A)					
1	DRDO patented biodigester septic tank (900 mm dia & 600 mm depth) with 100 mm thick cover slab, including transportation charges, etc.,	Numbers	1.00	10,000.00	10,000.00
2	Cement concrete 1:1-1/2:3 (one cement, one and a half sand and three hard broken stone jelly) using 20 mm gauge hard broken granite stone jelly for all RCC items of works excluding cost of reinforcement grill and fabricating charges centring and shuttering but including laying, vibrating with mechanical vibrators, finishing, curing, etc.	m ³	0.08	7,603.91	608.31

DRDO-patented Biodigester Septic Tank at Thiruvanaikovil, Trichy					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
3	Supplying and fixing in position of RCC ring well of 4' ring well with 1' height using cement mortar slush including lifting and fixing in position with proper gradient etc., complete complying as per standard specification as instructed or directed by the engineering in-charge.	Numbers	5	1,111.00	5,555.00
4	RCC ring 4' cover slab lifting and fixing in position with proper gradient etc.,	Numbers	1	900.00	900.00
5	Providing and supplying hard broken 40 mm Aggregate filling the pit with filling in foundation and basement including labour charges etc.	Numbers	0.39	980.00	382.20
6	Supplying and fixing in position best quality PVC soil / waste pipes of various dia having 6 kg / sq.cm. Pressure BIS mark and providing leak proof joints using PVC adhesives including fixing to the wall with special PVC / MS clamp, teak wood plugs, brass screws, etc.				
	110 mm dia PVC pipe	Numbers	3	250.00	750.00
	110mm dia Elbow	Numbers	3	110.00	330.00
	Vent pipe 2.5 m length (2 Numbers) Numbers	Running Metre	2	250.00	1,250.00
Total Material Cost (A)					19,775.51
Labour Cost & Maintenance (B)					
1	Skilled	Resource days	1	850.00	850.00
2	Helper - semiskilled	Resource days	2	700.00	1,400.00
3	Plumber	Resource days	1	900.00	900.00
4	Plumber helper	Resource days	1	800.00	800.00
Total Labour Cost & Maintenance (B)					3,950.00
Total Cost					23,725.51

DRDO-patented Biodigester Septic Tank at Thiruvanaikovil, Trichy					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
Containment Improvement – OpEx					
1	De-sludging cost whenever required	Resource days	1	2,000.00	2,000.00
2	Supply and filling of the inoculum from the registered agencies from DRDO based on the design requirement and volume of the treatment system	Litres	200	20.00	4,000.00
Total OpEx (per annum)					6,000.00
	Note:				
1	The provided amount is tentative only, based on the site conditions and assumptions actual cost may vary. This shall be used for the reference purpose only. For tendering and contract, separate actual BOQ shall be prepared based on the ULBs requirement and site conditions.				
2	The cost provided here is based on the market enquiry and PWD SOR reference				
3	GST and other taxes are not considered for the estimation.				

A5.3.1 Financials

Initial installation cost	The costs of the biodigester installation and initial operations are INR. 23,000.
Operating costs	<p>This includes the cost of de-sludging provision or bacterium addition whenever required or once in every two years. Cost for single de-sludging is INR 2,000. So, it is considered INR 1,000 for one year. Consider enzyme supply once in two years or whenever required which is INR 4,000 for once in two years.</p> <ul style="list-style-type: none"> • Maximum OPEX will be 6,000 for 2 years ~ INR 3,000 per annum. • Minimum OPEX will be 2,000 for 2 years ~ INR 1,000 per annum.
Replacement cost	<p>This includes the cost of repairing or replacing or reconstructing the septic tank after its 15-year lifespan. Including the cost of de-sludging and repairing or rectification of the minor issues in the tank, a lump sum amount of INR 8,000 is considered (consider de-sludging INR 2,000 + cleaning and disinfection 1,000 + Epoxy painting inside the pit INR 5,000), for once in every 15 years. For the maximum, consider demolishing and reinstallation expenses.</p> <p>So, total life cycle cost for the improvement as per DRDO patented biodigester with RCC ring and soak pit model is,</p> <ul style="list-style-type: none"> • Min – 13,800 + 15,000 + 8,000 = 36,800 (~ INR 37,000) • Max – 13,800 + 15,000 + 13,800 = 42,600 (~ INR 43,000)

A5.4 DRDO-patented Biodigester with PVC Drum Setup

(Containment improvement model for pits)

Figure A5.3: Installation of DRDO Bio Digester for Twin Pit



Source: CWIS, 2022

DRDO-patented Biodigester with PVC Drum Setup

Sl. No.	Description of Work	Unit	Qty	Rate	Amount
Containment Improvement – CAPEX					
1	Supplying and fixing in position of RCC ring well of 900mm ring well with 1' height using cement mortar. Including lifting and fixing in position with proper gradient etc.,	Numbers	6	500.00	3,000.00
2	Supply and filling of the inoculum from the registered agencies from DRDO based on the design requirement and volume of the treatment system	Litres	200	20.00	4,000.00
3	RCC ring 900mm cover slab	Numbers	2	500.00	1,000.00
4	200 litres PVC drum	Numbers	1	1200.00	1,200.00
5	Plastering with Cement Mortar 1:5 (one cement and five sand), 12mm thick including curing etc., complete	Square Metre	5.00	267.9	1,339.50

DRDO-patented Biodigester with PVC Drum Setup					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
	complying with standard specification as instructed or directed by the engineering in-charge (1 pit only)				
6	Providing and supplying hard broken 40 mm Aggregate filling the pit with filling in foundation and basement including labour charges etc., complete complying with standard specification as instructed or directed by the engineering in-charge	Cubic Metre	1.00	2000.00	2,000.00
7	Plumbing work				
	3" PVC pipe up to 1.5m length	Running metre	1.5	200.00	300.00
	3 " end cap	Numbers	2.00	85.00	170.00
	3" mm elbow	Numbers	2.00	85.00	170.00
	3" mm Tee	Numbers	2.00	90.00	180.00
	3" Vent pipe 2.2m length	Running metre	2.2	200.00	440.00
Total CapEx					13,799.50
Say,					13,800.00
Containment Improvement – OpEx					
1	De-sludging cost for once in 2 years (or) whenever required. In case loading of inoculum is required.	LS	1	1,000.00	1,000.00
Total OpEx (per annum)					1,000.00
	Note:				
1	Provided amount is tentative only, based on the site conditions and assumptions actual cost may vary. This shall be used for the reference purpose only. For tendering and contract separate actual BOQ shall be prepared based on the ULBs requirement and site conditions.				
2	The cost provided here is based on the market enquiry PWD SOR reference				
3	GST and other taxes are not considered for the estimation.				

A5.4.1 Financials

Initial installation cost	Cost of the biodigester installation and initial running cost INR. 13,800.00.
Operating costs	This includes the cost of de-sludging provision or bacterium addition whenever required, considered once in every two years. Cost for single de-sludging INR 2,000. So, it is considered INR 1,000 for one year. Total lifespan considered is 15 years = 15 x 1,000 = INR 15,000

Replacement cost	<p>This includes the cost of repairing or replacing or reconstructing the septic tank after its 15-year lifespan. Including the cost of de-sludging and repairing or rectification of the minor issues in the tank, lump sum amount of INR 8,000 is considered (consider de-sludging INR 2,000+ cleaning and disinfection 1,000+ Epoxy painting inside the pit INR 5,000), once in every 15 years.</p> <p>So, total life cycle cost for the improvement as per DRDO patented bio digester with RCC ring and soak pit model,</p> <ul style="list-style-type: none"> • Min – 13,800 + 15,000 + 8,000 = 36,800 ~ INR 37,000 • Max – 13,800 + 15,000 + 13,800 = 42,600 ~ INR 43 ,000
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A5.5 DRDO-patented FRP Biodigester with Anaerobic Filter

Figure A5.4 DRDO Fibre Reinforced Polymer (FRP) Biodigester



Source: CWIS, 2020

DRDO-patented FRP Biodigester with Anaerobic Filter

Sl. No.	Description of Work	Unit	Qty	Rate	Amount
Containment improvement – CapEx					
1	FRP Precast tank with inoculum designed for 8 users the capacity of the tank is 1KL consisting of 3 chambers with design load and specifications as per the guidance of the DRDO agency. The minimum wall thickness is 10 mm and required bacteria growth surface to be provided inside the 1 st digester.	Numbers	1	20,000.00	20,000.00
2	Construction of the anaerobic filters (Capacity of the AF – 1KLD) in the third chamber of the existing containment system. Which includes De-sludging, disinfection, construction of baffle wall, plastering around the inner walls, construction of pedestals, procurement	Lumpsum	1	12,000.00	12,000.00

DRDO-patented FRP Biodigester with Anaerobic Filter					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
	and laying of precast perforated slabs, Filling of Blue metals as filter materials, provision of the desludging pipes with end caps, (150mm dia 10 Kgs – 2 metre), disposal provision to the existing soak pit.				
3	Plastering with Cement Mortar 1:5 (One cement and Five sand), 12mm thick including curing etc., complete complying with standard specification as instructed or directed by the engineer in charge	Square metre	10.00	267.9	2,679.00
4	Providing and suppling hard broken 40 mm Aggregate filling the pit with filling in foundation and basement including labour charges etc., complete complying with standard specification as instructed or directed by the engineer in charge	Cubic metre	1.00	1250.00	1,250.00
5	Plumbing work				
	3" PVC pipe up to 5m length	Running metre	5.00	200.00	1,000.00
	3 " end cap	Numbers	2.00	85.00	170.00
	3" mm elbow	Numbers	2.00	85.00	170.00
	3"mm Tee	Numbers	2.00	90.00	180.00
	3"Vent pipe 2.5m length	Running metre	2.5	200.00	500.00
			Total CAPEX		37,949.00
			Say		38,000.00
Containment Improvement – OpEx					
1	De-sludging costs once in 2 years (or) whenever required. In case if needed Loading of enzymes is required.	Lumpsum	0.5	2,000.00	1,000.00
Total OpEx (per annum)					1,000.00
	Note:				
1	The provided amount is tentative only, based on the site conditions and assumptions actual cost may vary. This shall be used for the reference purpose only. For tendering and contract, separate actual BOQ shall be prepared based on the ULBs requirement and site conditions.				
2	The cost provided here is based on the market enquiry and PWD SOR reference				
3	GST and other taxes are not considered for the estimation.				

A5.5.1 Financials

Initial installation cost	The costs for biodigester installation and initial operations are INR. 38,000.
Operating costs	This includes the cost of de-sludging provision or bacterium addition whenever required or once in every two years. The cost for single de-sludging is INR 2,000. So, it is considered INR 1,000 for one year. The total lifespan considered is 15 years = 15 x 1,000 = INR 15,000.
Replacement cost	This includes the cost of repairing or replacing or reconstructing the septic tank after its 15-year lifespan. Including the cost of de-sludging and repairing or rectification of the minor issues in the tank, a lump sum amount of INR 10,000 is considered (consider de-sludging at INR 2,000 + cleaning and disinfection 1,000 + leakproof coat including the lifting of the tank INR 8,000), for once in every 15 years. So, total life cycle cost for the improvement is, <ul style="list-style-type: none"> • Min – 38,000 + 15,000 + 8,000 = INR 61,000. • Max – 38,000 + 15,000+ 38,000 = INR 91,000.

A5.6 DRDO-patented FRP Biodigester with Dispersion Pit

Figure A5.5:DRDO Biodigester (FRP) post installation



Source: CWIS, 2022

DRDO-patented FRP Biodigester with Dispersion Pit					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
Containment Improvement - Capex					
1	FRP precast tank with inoculum	Numbers	1.00	20,000.00	20,000.00
2	Plumbing work				

DRDO-patented FRP Biodigester with Dispersion Pit					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
	3" PVC pipe	Running metre	4.00	200.00	800.00
	3 " end cap	Numbers	2.00	85.00	170.00
	3" mm elbow	Numbers	2.00	85.00	170.00
	3"mm Tee	Numbers	2.00	90.00	180.00
	3"Vent pipe 2.5m length	Running metre	2.50	20.00	500.00
3	Soak pit				
	Supplying and filling of broken 40 mm blue metal to fill the pit including labour for shifting and excavating if needed, etc., completely complying with standard specifications as instructed or directed by the engineer in charges	Cubic metre	1.00	2,000.00	2,000.00
	Labour charges for the installation of the biodigester - 1 fitter and 4 helpers for 2 hours	Set	1	2,000.00	2,000.00
			Total CAPEX		25,820.00
Containment Improvement - OpEx					
1	De-sludging costs once in 2 years (or) whenever required. In case if needed loading of enzymes is required.	Trips	0.5	2,000.00	1,000.00
			Total OpEx (per annum)		1,000.00
	Note:				
1	The provided amount is tentative only, based on the site conditions and assumptions actual cost may vary. This shall be used for the reference purpose only. For tendering and contract, separate actual BOQ shall be prepared based on the ULBs requirement and site conditions.				
2	The cost provided here is based on the market enquiry and PWD SOR reference				
3	GST, transportation, and other taxes are not considered for the estimation.				

A5.6.1 Financials

Initial installation cost	The costs for biodigester installation and initial operations are INR. 25,820.
Operating costs	This includes the cost of de-sludging provision or bacterium addition whenever required or once in every two years. The cost for single de-sludging is INR 2,000. So, it is considered INR 1,000 for one year. The total lifespan considered is 15 years = 15 x 1,000 = INR 15,000.

Replacement cost	<p>This includes the cost of repairing or replacing or reconstructing the septic tank after its 15-year lifespan. Including the cost of de-sludging and repairing or rectification of the minor issues in the tank, a lump sum amount of INR 8,000 is considered (consider de-sludging at INR 2,000 + cleaning and disinfection 1,000 + Epoxy painting inside the pit INR 5,000), for once in every 15 years.</p> <p>So, total life cycle cost for the improvement is,</p> <ul style="list-style-type: none"> • Min – 26,000 + 15,000 + 8,000 = INR 49,000. • Max – 26,000 + 15,000 + 26,000 = INR 67,000.
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A5.7 RCC Pipe Septic Tank without Disposal Arrangement

RCC Pipe Septic Tank without Disposal Arrangement					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
RCC Pipe Septic Tank - Capex					
1	RCC pipe septic tank – NP3 specification (600 mm dia & 2500 mm length) with access cover, including transportation charges, etc.	Numbers	1	13,000.00	13,000.00
2	Supplying and fixing in a position best quality PVC soil/waste pipes of various dia having 6 kg / sq.cm. Pressure BIS mark and providing leak proof joints using PVC adhesives including fixing to the wall with special PVC / MS clamp, teak wood plugs, brass screws, etc.,				
	75 mm dia PVC pipe (Site specific)	Running metre	10.00	200.00	2,000.00
	75 mm Dia PVC crown	Number	1.00	65.00	65.00
3	Supplying PVC Specials (with working pressure 10 kg. / sq.cm.) In water supply arrangements (both internal and external water supply arrangements etc. Approved the as instructed or directed by the engineer in-charge.				
	75 mm dia Elbow	Numbers	1.00	85.00	85.00
	Vent pipe 2.5 m in length	Running metre	1.00	200.00	500.00
4	PCC for the bedding of the pipe which includes excavation and bringing materials to the site, laying cement concrete with the ratio 1:4:8 curing, etc.	Lump sum	1	2,950.00	2,950.00
5	Fixing labour charges Plumber and helper	Resource day	1.00	1,550.00	1,550.00

RCC Pipe Septic Tank without Disposal Arrangement					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
6	Cost allocated for Hydrostatic test with labour and rectification of the leaks if any.	Item	1.00	4,000.00	4,000.00
7	Supply and installation of precast junction chamber of size 450X450X300 mm for the provision of disposal arrangement and inspection purpose	Numbers	1.00	800.00	800.00
Total Capex					26,950.00
Say					27,000.00
RCC Pipe Septic Tank – OpEx					
1	De-sludging cost once in 1 year or whenever required	Trips	1	2,000.00	2,000.00
Total OpEx (per annum)					2,000.00
Note:					
1	The provided amount is tentative only, based on the site conditions and assumptions actual cost may vary. This shall be used for the reference purpose only. For tendering and contract, separate actual BOQ shall be prepared based on the ULBs requirement and site conditions.				
2	The cost provided here is based on the market inquiry and PWD SOR reference				
3	GST and other taxes are not considered for the estimation.				
4	Based on the quantum of the work the rates will be reduced further; presently it is considered for installation of a single unit.				

A5.7.1 Financials

Initial installation cost	The costs for biodigester installation and initial operations are INR. 27,000.
Operating costs	This includes the cost of de-sludging provision or bacterium addition whenever required or once in every two years. The cost for single de-sludging is INR 2,000. So, it is considered INR 1,000 for one year. The total lifespan considered is 15 years = 15 x 1,000 = INR 15,000
Replacement cost	This includes the cost of repairing or replacing or reconstructing the septic tank after its 15-year lifespan. Including the cost of de-sludging and repairing or rectification of the minor issues in the tank, a lump sum amount of INR 8,000 is to be considered (consider de-sludging INR 2,000 + cleaning and disinfection 1,000 + Epoxy painting inside the pit INR 5,000), for once in every 15 years. So, total life cycle cost for the improvement for RCC Pipe septic tank without disposal arrangement is <ul style="list-style-type: none"> • Min – 27,000 + 15,000 + 8,000 = INR 50,000. • Max – 27,000 + 15,000 + 27,000 = INR 69,000.

A5.8 Containment Improvement by Earthworm-based Bioreactor

Containment with Bioreactor and Primary Settler Tank - Capex					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
1	Brick work in cement mortar 1:5 using best quality of country bricks of size 8-3/4" x 4-1/4" x 2-1/4" for foundation and basement including curing, etc., complete complying with standard specification.	Cubic metre	3.60	5,135.5	18,487.8
2	Plastering with cement mortar 1:5 (one cement and five sand), 12 mm thick in all floors including curing etc. Complete complying with standard specification as instructed or directed by the engineer in-charge	Square metre	3.60	209.63	754.668
3	Volume of bioreactor filled with cocopeat 2520 L; weight of cockpit required 168 kg per yearly twice	kg	336	27	9,072.00
4	Drainage layer				
	Provide 20 mm, 40 mm aggregates in layers of 10cm depth				
	Volume of 20mm aggregates required	Cubic metre	0.432		2,000.00
	Volume of 40mm aggregates required	Cubic metre	0.432		2,000.00
	1mm - Plastic net between cocopeat and drainage layer	LS	1		500.00
5	Primary settler 2.0mx1.6mx0.6m (PVC Tank)	Number	1	10,000	10,000.00
6	Supply, installation, and commissioning of a 0.5 HP Crompton submersible pump including plumbing and electricals as required	Unit	1	12,000	12,000.00
7	Supply and laying of 50 mm PVC Pipe with Min 14 kgs pressure holding capacity (with 30% extra head for practical purposes - friction losses, horizontal length of piping etc.,)	Number	1	5,000	5,000.00
8	Supply and installation of Automatic time controller with required switch control and electrical fixtures and wires.	Set	1	10,500	10,500.00
9	Electrical work – labour charges including miscellaneous purchase (2 Electrician and helpers)	LS	1	5,000	5,000.00
10	Cost of the civil materials and installation for the construction of the bio reactor with the following specifications size of the reactors is 1.5 m x 2.0 m x 1.8 m (3 KLD effective capacity), bottom slab with RCC M25 grade of	Set	1	64,000	64,000.00

Containment with Bioreactor and Primary Settler Tank - Capex					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
	Min 250 mm depth, wall thickness 230 mm min with plastered both side (inner and outer 20 mm – 12 mm 1 st coat and 8 mm with water proofing agent second coat), roof slab with 100 mm thick M20 grade to hold 1KL PVC tank and fixtures above the slab, with required skilled labour with the supervision of the site in charge. The cost is provided here is as per the actual cost expenditure during the implementation (Nov-Dec 2021).				
11	Cost of the cleaning work which is including mechanical equipment (JCB) hiring charges and bill paid to the hour basic output (Actual as per site condition)	Hours	3	1,500	4,500.00
Total CAPEX (say)					1,41,815.00
Bio reactor and containment – OpEx					
1	De-sludging cost for once in 1 year or whenever required	Trips	1	2,000.00	2,000.00
2	Cocopeat replace cost once in year	Numbers	1	2,500.00	2,500.00
3	Energy consumption for the pump per annum (consider	Rupees	1	5,000	5,000.00
Total OpEx (per annum)					9,500.00
Note:					
1	Provided amount is tentative only, based on the site conditions and assumptions actual cost may vary. This shall be used for the reference purpose only. For tendering and contract separate actual BOQ shall be prepared based on the ULBs requirement and site conditions.				
2	The cost provided here is based on the market enquiry and PWD SOR reference				
3	GST and other taxes are not considered for the estimation.				
4	Energy consumption is considered as part of the regular payment towards the toilet operations. Considering 1 HP pump ran for 23 times in a day for 1 min. Considered around INR 200 per month.				
5	De-sludging cost before intervention is not added with this estimate.				

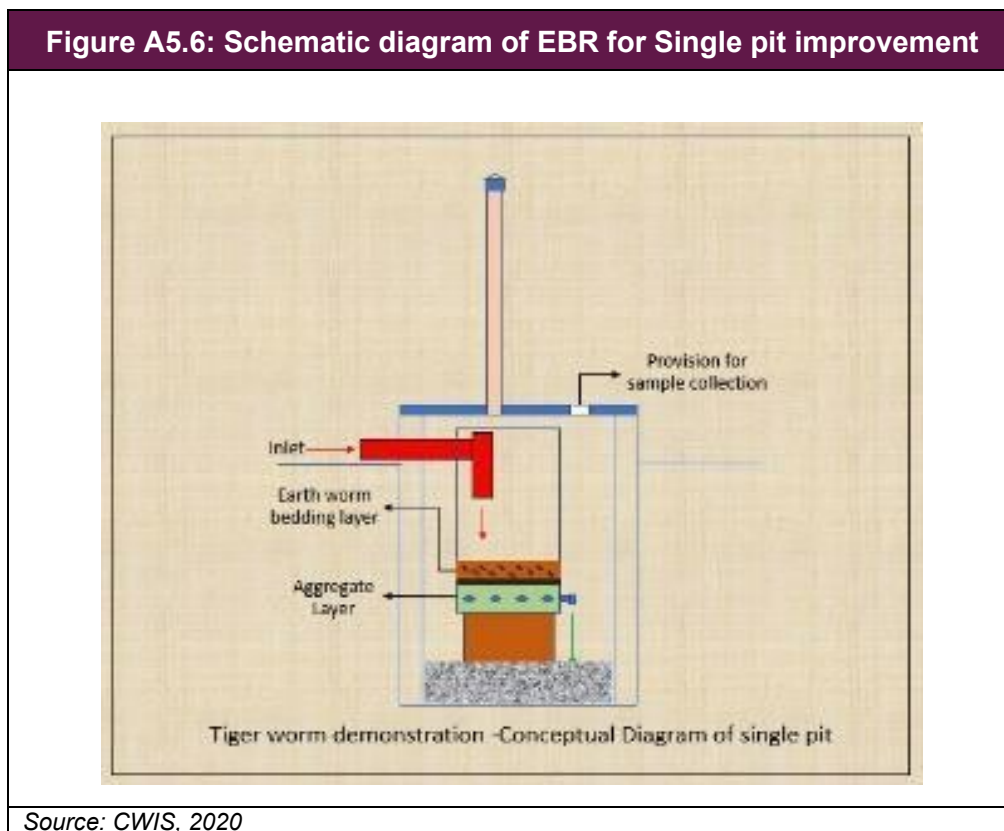
A5.8.1 Financials

Initial installation cost	The costs for biodigester installation and initial operations are INR. 1,41,000.
Operating costs	<p>This includes the cost of cocopeat, earthworms and energy consumption, amounting to INR 10,500.</p> <ul style="list-style-type: none"> • Cost of cocopeat replacement once in a year - INR 2,500 • Cost of dosing earth worms whenever required or yearly once. - INR 3,000/ year

	<ul style="list-style-type: none"> • Energy consumption for the pump - INR 5,000 per annum <p>This includes the cost of de-sludging the tank once in every 3 years. The market rate at Trichy is INR 2,500 for every trip, based on the following assumptions:</p> <ul style="list-style-type: none"> • Removal of blockages in the feeder line to septic tank • Not more than 3 lengths of the pipe joint during de-sludging • Not more than 10 km (distance on road) between collection and disposal points
Replacement cost	<p>This includes the cost of repairing or replacing or reconstructing the septic tank after its 15-year lifespan. Considering a minimum expenditure for pump replacement and other rectification work, amounting to INR 12,500 and maximum expense for removal of materials inside the EBR, one coat of water proofing, hydrostatic test and recommissioning cost at INR 56,400, the total life cycle cost for the EBR improvement method is,</p> <ul style="list-style-type: none"> • Min – $1,41,000 + (10,500 \times 15) + 12,500 = \text{INR } 3,11,000.$ • Max – $1,41,000 + (10,500 \times 15) + 56,400 = \text{INR } 3,54,900 \sim \text{INR } 3,55,000.$

A5.9 Containment Improvement by Earthworm-based Bioreactor – IHHL

(For septic tank and single pit)



Containment Improvement by Earthworm-based Bioreactor – IHHL					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
Containment Improvement – Capex					
1	Supply and installation of 200 litres PVC drum with required fixtures for the primary earth worm bioreactor	Numbers	1.00	450.00	450.00
2	Supplying and fixing in position of RCC ring of 300 mm dia to provide bottom support to the PVC drum and raise the digester to improve the drain facility	Numbers	2	250.00	500.00
3	Plumbing work				
	4" PVC pipe up to 1.5m in length	Running metre	1.50	250.00	375.00
	4"mm Tee	Numbers	1.00	135.00	135.00
	2" PVC pipe for the drain system	Running metre	2.50	70.00	175.00
4	Supply and filling of 40 mm blue metal for the draining layer	Cubic metre	0.25	1,850.00	462.50
5	Labour cost for the installation work Plumber and helper 0.5 sets (half day work)	Set	0.5	1,550.00	775.00
6	Supply and fill the Tiger worms as required (1 Kg preferred)	Kilogram	1	650.00	650.00
				Total CAPEX	3,522.50
Containment Improvement – OpEx					
1	Dosing of earthworms whenever required or yearly once	kg	3	650.00	1,950.00
				Total OpEx (per annum)	1,950.00
	Note:				
1	The provided amount is tentative only, based on the site conditions and assumptions actual cost may vary. This shall be used for the reference purpose only. For tendering and contract, separate actual BOQ shall be prepared based on the ULBs requirement and site conditions.				
2	The cost provided here is based on the market enquiry and PWD SOR reference				
3	GST and other taxes are not considered for the estimation.				

A5.9.1 Financials

Initial installation cost	The costs for biodigester installation and initial operations are INR. 3,522.
Operating costs	This includes the cost of dosing earthworms whenever required or annually, amounting to INR 2,000 for one year. The total lifespan considered is 15 years = 15 x 2000 = INR 30,000.
Replacement cost	This includes the cost of repairing or replacing or reconstructing the septic tank after its 15-year lifespan. Including the cost of de-sludging and repairing or rectification of the minor issues in the tank, a lump sum amount of INR 2,000 is

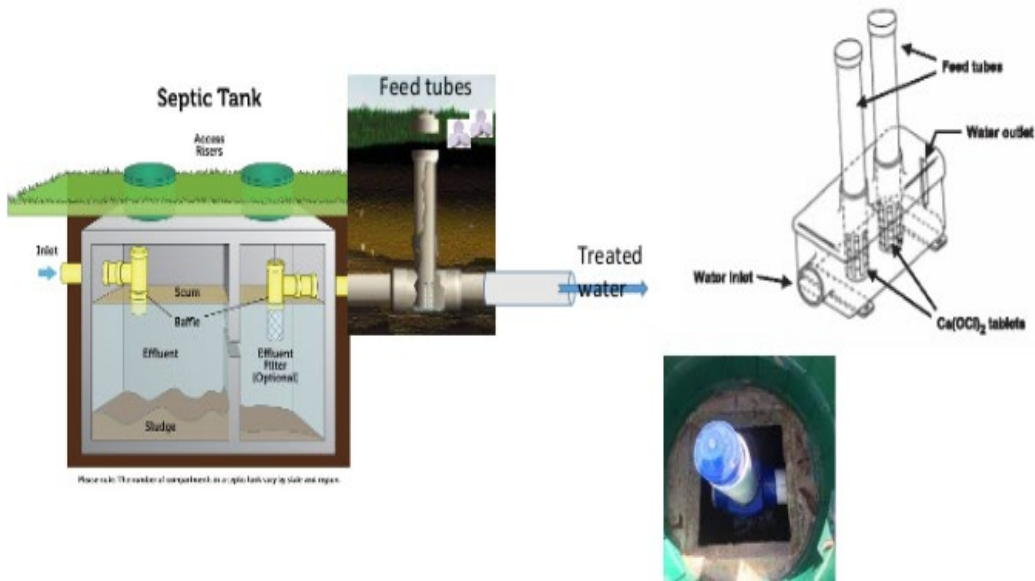
considered (cleaning and disinfection 1,000 + Wear and tear of pipelines INR 1,000), once in every 15 years.

So, total life cycle cost for the tiger worm bioreactor improvement method is,

- Min – 3,500 + 30,000 + 2,000 = 30,500 ~ INR 36,000.
- Max – 3,500 + 30,000 + 3,500 = INR 37,000.

A5.10 Manual Chlorine Tablet System

Figure A5.7: Installation of Manual Chlorinator at Septic Tank Outlet



Source: CWIS, 2022

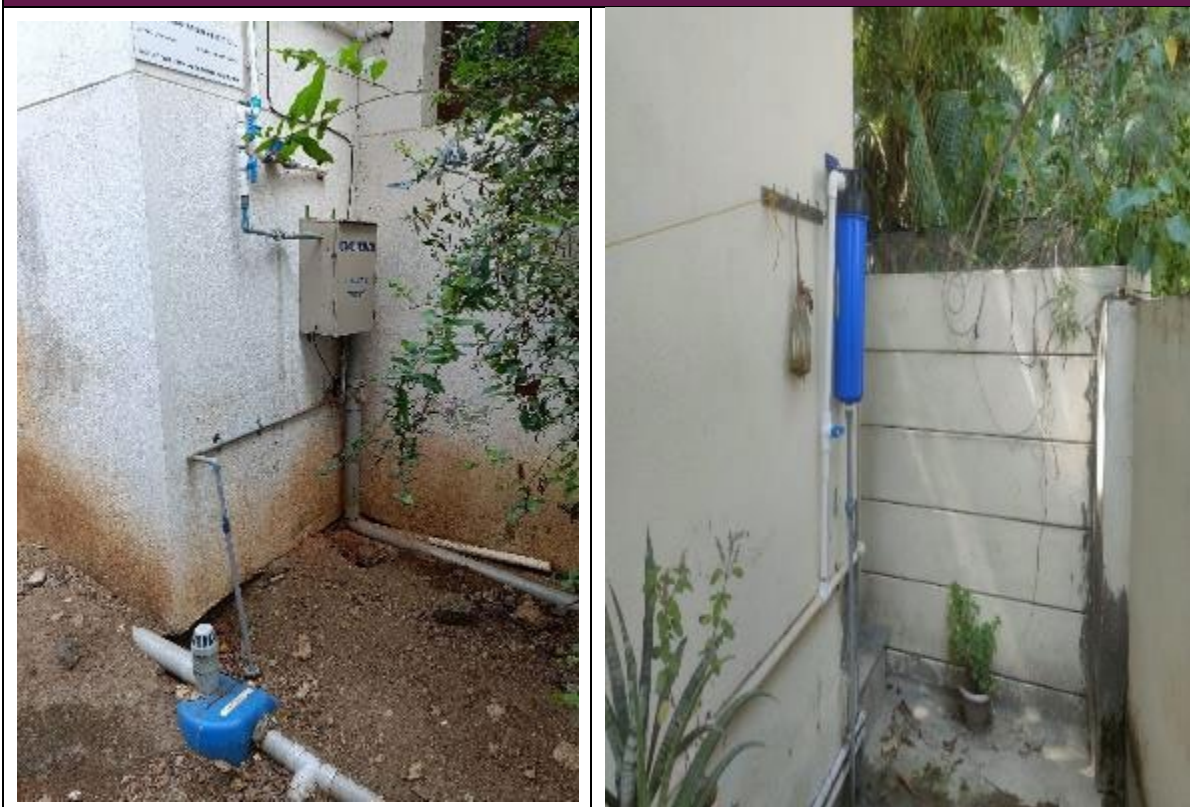
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
Manual Chlorine Tablet System - Capex					
1	Supplying and fixing in a position best quality PVC soil/waste pipes of various dia having 6 kg / sq.cm. Pressure BIS mark and providing leak proof joints using PVC adhesives including fixing to the wall with special PVC / MS clamp, teak wood plugs, brass screws, etc.,				
	110 mm dia. PVC pipe	Running metre	4.00	250.00	1,000.00
2	Supplying PVC Specials (with working pressure 10 kg. / sq.cm.) In water supply arrangements (both internal and external water supply arrangements etc. Approved the as instructed or directed by the engineer in charge.				
	110mm dia. Elbow	Numbers	2.00	110.00	220.00
	110mm dia PVC tee	Numbers	3.00	135.00	405.00
	110mm dia. End cap	Numbers	1.00	110.00	110.00
	50 litres PVC drum	Numbers	1.00	450.00	450.00
3	Chlorine tablet initial requirement	Kilogram	1.00	530.00	530.00
4	Labour cost for the installation work 1 plumber	Resource day	1.00	900.00	900.00
Total Capex					3,615.00
Manual Chlorine Tablet System - OpEx					
1	Chlorine tablet cost once in 1 year or whenever required	Kilogram	1	530.00	530.00
Total OpEx (per annum)					530.00
	Note:				
1	The provided amount is tentative only, based on the site conditions and assumptions actual cost may vary. This shall be used for the reference purpose only. For tendering and contract, separate actual BOQ shall be prepared based on the ULBs requirement and site conditions.				
2	The cost provided here is based on the market enquiry, latest purchase prices, and SOR references.				
3	GST and other taxes are not considered for the estimation.				

A5.10.1 Financials

Initial installation cost	The costs for biodigester installation and initial operations are INR 3,615.
Operating costs	This includes the cost of chlorine tablets, whenever required. It is estimated that 8 tablets (INR 106 per piece) are required every year, amounting to INR 850 for one year. The total lifespan considered is 15 years = 15 x 850 = INR 12,750. Say INR 13,000.
Replacement cost	This includes the cost of repairing or replacing or reconstructing the septic tank after its 15-year lifespan. Including the cost of de-sludging and repairing or rectification of the minor issues in the tank, a lump sum amount of INR 2,000 is considered (cleaning and disinfection 1,000 + wear and tear of pipelines INR 1,000), for once in every 15 years. So, total life cycle cost for the manual chlorine tablet improvement method is, <ul style="list-style-type: none"> • Min – 4,000 + 13,000 + 2,000 = INR 19,000. • Max – 4,000 + 13,000 + 4,000 = INR 21,000.

A5.11 Automatic Chlorine Tablet System

Figure A5.8: Installed Automatic Chlorine Tablet System



Source: CWIS, 2022

Automatic Chlorine Tablet System					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
Automatic Chlorine Tablet system – Material Cost (A)					
1	Supplying and fixing in a position best quality PVC soil/waste pipes of various dia having 6 kg / sq.cm. Pressure BIS mark and providing leak proof joints using PVC adhesives including fixing to the wall with special PVC / MS clamp, teak wood plugs, brass screws, etc.				
	110 mm dia. PVC pipe	Running metre	5.00	250.00	1,250.00
2	Supplying PVC Specials (with working pressure 10 kg. / sq.cm.) In water supply arrangements (both internal and external water supply arrangements etc. Approved the as instructed or directed by the engineer in-charge.				
	110mm dia. Elbow	Numbers	4.00	110.00	440.00
	110mm dia End cap	Numbers	4.00	250.00	1,000.00
	50 litres PVC drum	Numbers	1.00	450.00	450.00
3	Chlorine tablet initial requirement	Kilogram	1.00	500.00	500.00
4	Automatic time setup with electricity charges	Numbers	1.00	3,000.00	3,000.00
Total					6,640.00
Labour Cost & Maintenance (B)					
1	Plumber	Resource days	1	900.00	900.00
2	Plumber helper	Resource days	1	800.00	800.00
3	Skilled Labour	Resource days	1	850.00	850.00
Total Labour Cost & Maintenance (B)					2,550.00
Total (A+B)					9,190.00
Automatic Chlorine Tablet system - OpEx					
1	Chlorine tablet cost once 1 year or whenever required	Kilogram	1	530.00	530.00
2	De-sludging cost whenever required	Numbers	1	1000.00	1,000.00

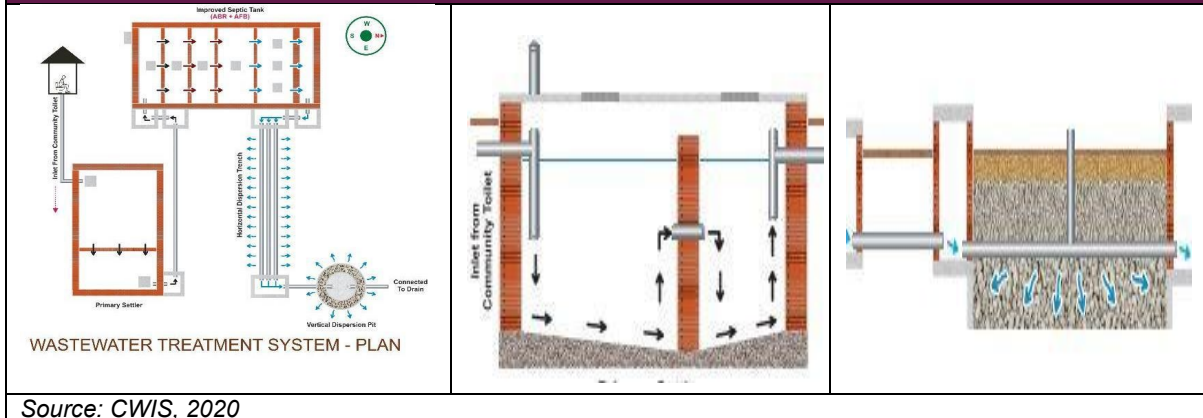
Automatic Chlorine Tablet System					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
Total OPEX (per annum)					1,530.00
	Note:				
1	The provided amount is tentative only, based on the site conditions and assumptions actual cost may vary. This shall be used for the reference purpose only. For tendering and contract, separate actual BOQ shall be prepared based on the ULBs requirement and site conditions.				
2	The cost provided here is based on the market enquiry, latest purchase prices, and SOR references.				
3	GST and other taxes are not considered for the estimation.				

A5.11.1 Financials

Initial installation cost	The costs for biodigester installation and initial operations are INR 9,190.
Operating costs	<p>This includes the cost of chlorine tablets whenever required. It is estimated that 5 tablets (INR 106 per piece) are required every year, amounting to INR 530 for one year.</p> <p>The total lifespan considered is 15 years = 15 x 530 = INR 7,950. Say INR 8,000.</p>
Replacement cost	<p>This includes the cost of repairing or replacing or reconstructing the septic tank after its 15-year lifespan. Including the cost of de-sludging and repairing or rectification of the minor issues in the tank, a lump sum amount of INR 2,000 is considered (cleaning and disinfection 1,000 + wear and tear of pipelines INR 1,000), once in every 15 years.</p> <p>So, the total life cycle cost for Automatic Chlorine tablet improvement method is,</p> <ul style="list-style-type: none"> • Min – 9,000 + 8,000 + 2,000 = INR 19,000 • Max – 9,000 + 8,000 + 9,000 = INR 26,000

A5.12 Containment Improvement by Primary Settler and Improved Septic Tank with Disposal Arrangements

Figure A5.9: Containment improvement by primary settler and improved septic tank with disposal arrangements



Containment Improvement by Primary settler and Improved septic tank with disposal arrangements

S No	Description of Work	Unit	Qty	Rate	Amount
1	Construction of settler with the size of 4.58 M X 2.41 M outer dimension with 8" outer wall provided with 2 Chamber of 600X600X450 mm size. The settler consisting with 2 chambers of 2.5 X 1.5 and 1.5 X 1.25 Size with 4" partition wall, the required pipes and CI covers, the levels are to be done as per the site condition. All the activities are to be followed as per the drawing and specification provided in the scope of work. The activities include excavation by following safe excavation procedure as per Indian Standard, providing PCC with 1:5:10 ratio, providing RCC floor with M20 grade concrete including RCC and cantering, shuttering and provision of manhole and other required miscellaneous items as directed and instructed by the engineer in-charge in line with the detailed estimate. The activities include curing, reinforcement and painting with approved quality of cement and emulsion paint with prior approval from the engineer in-charge	Unit	1.00	1,60,877	1,60,877.00

Containment Improvement by Primary settler and Improved septic tank with disposal arrangements					
S No	Description of Work	Unit	Qty	Rate	Amount
2	Retrofitting of existing septic tank with the size of 6.93 X 2.41 X 2.2 M outer dimension with 8" outer wall provided with 2 Chambers of 600X600X450 mm size. The Improved Septic tank (IST) consisting with 5 chambers min size of 2.1 X 0.8 X 2.1 - 3 numbers and 2.1 X 1.2 X 2.1 M – 2 numbers with fixed bed anaerobic filter including supply and fixing position the precast slab and pipes, and filter media like cinders. The required pipes and CI covers, the levels are to be done as per the site condition. All the activities are to be followed as per the drawing and specification provided in the scope of work. The activities include excavation by following safe excavation procedure as per Indian standard, providing PCC with 1:5:10 ratio, providing RCC floor with M20 grade concrete including RCC and centring, shuttering and provision of manhole and other required miscellaneous items as directed and instructed by the engineer in-charge in line with the detailed estimate. The activities include curing, reinforcement and painting with approved quality of cement and emulsion paint with prior approval from the engineer in-charge.	Unit	1.00	1,99,630	1,99,629.00
3	Construction of dispersion system with 2 registers or access chambers, from the IST To soak pit min 10 m 2 parallel 4" PVC pipe with slope and specification as provided in the drawing and filter media of 70-50 mm size 1.00 m min below the pipe surface and min 200 m above the pipe covered with min 500 micron polythene sheet to avoid rain water penetration into the system, the sheet may extend 300 mm min either side of the trench and over the sheet earth filling with standard compaction procedure to be done	Unit	1.00	48,285	48,285.00
4	Construction of soak pit in the specified location by the engineer in-charge as per drawing	Unit	1.00	22,394	22,394.00
Total					437,184.00

OpEx					
1	Provision for monthly maintenance and cleaning work in and around the Improved septic tank	Monthly	12	250	3,000.00
2	Containment de-sludging by once 3 years (Primary settler, Improved septic Tank & Soak pit)	Unit	2.00	3,000.00	6,000.00
3	Chlorine disinfection unit - Chlorine tablet cost by yearly once	Kg	2.00	530.00	1,060.00
4	Cleaning of Filter materials and refilling it back to Anaerobic filter once in 5 years (Rs.40,000/5 = 8,000)	LS	1.00	8,000	8,000.00
Total					15,060.00

Detailed abstract for Primary settler (based on RMS colony demonstration - 7 KLD design)					
S No.	Description of Work	Unit	Qty	Rate	Amount
Settler					
1	Ordinary soil SS20B earth work excavating and depositing on bank with initial lead of 10m & initial lift of 2m in sand, silt or other loose soil, wet sand or silt not under water, light black cotton soil, sandy loam and ordinary soil including excavated earth etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Cubic metre	67.00	58.91	3,947.00
2	Refilling with excavated earth other than sand with an initial head load of 100 m and depositing the earth as shown by the departmental officers; in layers of not more than 15 cm thick well rammed, watered and consolidated etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Cubic metre	6.00	30.8	185.00
3	Supplying and filling in foundation, basement, etc. with filling sand in layers of not more than 15 cm thick well-watered, rammed and consolidated etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Cubic metre	2.00	1,489.2	2,978.40
4	Cement concrete 1:5:10 (one Cement, five sand and ten hard broken stone jelly) using 40 mm gauge hard broken granite stone jelly for	Cubic metre	2.50	4,253.3	10,633.00

Detailed abstract for Primary settler (based on RMS colony demonstration - 7 KLD design)

S No.	Description of Work	Unit	Qty	Rate	Amount
	foundation including dewatering wherever necessary and laid in layers of not more than 15 cm thick well rammed, consolidated and curing etc., complete complying with standard specification as instructed or directed by the engineer in-charge				
5	Providing and laying in position, standardised concrete mix M-20 grade in accordance with IS:456-2000, using 20mm and downgraded hard broken granite stone jelly for all RCC items of works with minimum cement content of 325 kg/m ³ and maximum water cement ratio of 0.55, including admixture (plasticiser/ super plasticiser) in recommended proportions as per IS:9103 to accelerate, retard setting of concrete, improve workability without impairing strength and durability with about (5 cu.m.) 7730 kg. of 20mm machine crushed stone jelly and with about (3.3 cu.m.) 5156 kg. of 10-12mm machine crushed stone jelly and with about (4.79 cu.m.) 7670 kg. of sand, but excluding cost of reinforcement grill and fabricating charges, centring, and shuttering and also including laying, vibrating with mechanical vibrators, finishing, curing, etc. and providing fixtures like fan clamps in the RCC floor/ roof slabs wherever necessary without claiming extra, etc., complete complying with standard specification as instructed or directed by the engineering in charge. The coarse and fine aggregates to be used should comply with the requirements of IS (No separate payment will be made by the Department for the excess usage of materials)	Cubic metre	6.00	11,587.6	69,526.00
6	Brick partition wall in CM 1:3 using country bricks 8 3/4" x 4 1/4" x 2 1/4" including plastering CM 1:5, 12mm thick on both sides etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Cubic metre	10.00	5,135.5	51,355.00
7	Supplying and fixing in position best quality PVC soil / waste pipes of various dia having 4 kg / sq.cm. Pressure BIS mark and providing leak proof joints using PVC adhesives including fixing to the wall with special PVC / MS clamp, teak wood plugs, brass screws,				

Detailed abstract for Primary settler (based on RMS colony demonstration - 7 KLD design)					
S No.	Description of Work	Unit	Qty	Rate	Amount
	etc., and making connection to all sanitary fittings, dismantling masonry / RCC works wherever found necessary and making the good dismantled portion to the original condition, including testing for any leakages, etc., complete complying with standard specification as instructed or directed by the engineering in charge (The PVC pipes should be got approved by the as instructed or directed by the engineering in charge). The rate for earth work excavation will be measured and paid separately in the cases where the pipelines are proposed to be laid below				
	110mm pipe	Running metre	4.50	480	2,160.00
8	Plastering with Cement Mortar 1:5 (One cement and Five sand), 12mm thick in all floors including curing etc., complete complying with standard specification as instructed or directed by the engineer in charge	Square metre	75.00	267.9	20,093.00
TOTAL					1,60,877.00

Detailed abstract - Improved septic tank					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
Improved Containment - Septic tank					
1	Earth work open excavation in all soils and sub-soils and to full depth as may be directed except in rock requiring blasting inclusive of shoring shuttering, bailing out water wherever necessary and depositing the excavated earth with a lead of 10 mts. within the compound in places shown by the departmental officers and clearing and levelling the site, etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Cubic metre	27.00	58.91	1,590.57

Detailed abstract - Improved septic tank					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
2	Cement concrete 1:5:10 (one cement, five sand and ten hard broken stone jelly) using 40 mm gauge hard broken granite stone jelly for foundation including dewatering wherever necessary and laid in layers of not more than 15 cm thick well rammed, consolidated and curing, etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Cubic metre	0.37	4,253.3	1,573.72
3	Plain Cement Concrete 1:2:4 using 20 mm gauge hard broken granite stone jelly for foundation including dewatering wherever necessary and laid in layers of not more than 15 cm thick well rammed, consolidated and curing, etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Cubic metre	0.36	5,735.42	2,064.75
4	Brick work in cement mortar 1:5 using best quality of country bricks of size 8-3/4" x 4-1/4" x 2-1/4" for foundation and basement including curing, etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Cubic metre	2.08	5,135.5	10,681.84
5	Brick partition walls of 11.50cm thickness using best quality II class table moulded chamber burnt bricks of size 9" x 4-1/2" x 3" in cement mortar 1:3 (one cement and three sand) using hoop iron reinforcement if found necessary including curing, etc., complete complying with standard specification as instructed or directed by the engineer in-charge (Hoop iron reinforcement will be measured and paid for separately) in foundation and basement	Cubic metre	13.00	5,573.46	72,454.98
6	Cement concrete 1:1½:3 (one cement, one and half sand and three hard broken stone jelly) using 20 mm gauge hard broken granite stone jelly for all RCC items of works excluding cost of reinforcement grill and fabricating charges, centring, and shuttering but including laying, vibrating with	Cubic metre	3.17	6,361.9	20,167.22

Detailed abstract - Improved septic tank					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
	mechanical vibrators, finishing, curing, etc., complete complying with standard specification as instructed or directed by the engineer in-charge				
7	Plastering with cement mortar 1:3 (one cement and three sand) 12mm thick with WPC @ 2% by weight of cement including finishing, curing, etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Square metre	125.00	239.02	29,877.50
8	Painting one coat of old plastered wall surface with ready mixed plastic emulsion paint of first-class quality and of approved colour including thorough scrapping, clean removal of dirt, and including necessary plaster of Paris putty, wherever required, etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Square metre	55.00	197.4	10,857.00
9	Supplying and fixing PVC ventilating shaft of 110mm dia (having working pressure 4 kg. / sq.cm) with 3-meter height including cost of PVC cylindrical cowl of best approved quality etc., complete complying with standard specifications and as directed by the departmental officers	Numbers	2.00	70	140.00
10	Supplying and providing cinder or pebbles as filter media in the filter chamber of best approved quality as per standard specification., complete complying with standard specification as instructed or directed by the engineer in-charge	Cubic metre	3.46	1,250.69	4,327.39
11	Manufacturing, supplying and fixing precast RCC slabs of 50mm thickness in RCC 1:2:4 (one cement, two sand and four aggregates), using 20mm HBGS jelly including cost of reinforcement steel in position but including cost of moulding charges, casting of slabs, finishing, curing and fixing in position in all floors, etc., complete complying with standard	Square metre	5.76	2,845.4	16,389.50

Detailed abstract - Improved septic tank					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
	specification as instructed or directed by the engineer in-charge				
12	Supply and fixing in position CI Manhole cover with CI frames (heavy-duty) of size 60cm x 60cm with locking arrangements as directed by the departmental officers. The manhole cover frame and cover hold be light weight conforming to ISI, etc.	Numbers	7.00	2,200	15,400.00
13	Supplying and fixing in position best quality PVC soil / waste pipes of various dia having 4 kg / sq.cm. Pressure BIS mark and providing leak proof joints using PVC adhesives including fixing to the wall with special PVC / MS clamp, teak wood plugs, brass screws, etc.				
A	110mm upvc Pipe	Running metre	18.00	480	8,640.00
B	160mm upvc Pipe	Running metre	4.00	549	2,196.00
14	Supplying and laying of UPVC Specials, etc., complete complying with standard specification as instructed or directed by the engineering in-charge				
A	110mm UPVC Tee	Numbers	16.00	199	3,184.00
B	End Cap PF 110mm	Numbers	1.00	85	85.00
TOTAL					1,99,629.5
Say,					1,99,630.00

Detailed Abstract - Dispersion trench					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
1	Earth work open excavation in all soils and sub-soils and to full depth as may be directed except in rock requiring blasting inclusive of shoring shuttering, bailing out water wherever necessary and depositing the excavated earth with a lead of 10 m within the compound in places shown by	Cubic metre	15.53	58.91	914.87

Detailed Abstract - Dispersion trench					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
	the departmental officers and clearing and levelling the site, etc., complete complying with standard specification as instructed or directed by the engineer in-charge				
2	Hard broken granite stone jelly (I.S.S.) machine-crushed / HBGS jelly 20 mm size etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Cubic metre	13.72	1,250.69	17,159.47
3	Hard broken granite stone jelly (I.S.S.) machine-crushed / HBGS jelly 50 mm size etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Cubic metre	10.69	1,250.69	13,369.88
4	Supplying and fixing in position best quality PVC soil / waste pipes of various dia having 4 kg / sq.cm. pressure BIS mark and providing leak proof joints using PVC adhesives including fixing to the wall with special PVC / MS clamp, teak wood plugs, brass screws, etc.,				
A	110 mm Dia	Running metre	20.00	480	9,600.00
5	Supplying PVC Specials (with working pressure 10 kg. / sq.cm.) In water supply arrangements (both in internal and external water supply arrangements etc., complete complying with standard specification as instructed or directed by the engineer in charge				
A	110 mm end cap	Numbers	2.00	70	140.00
B	110 mm elbow	Numbers	2.00	163.71	327.42
C	110 mm Tee	Numbers	2.00	199.02	398.04
6	Supply and fixing of plastic cover / plaster over the dispersion pipe to avoid soil or aggregate disturbing the pipeline etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Square metre	15.00	35	525.00
7	Construction of inlet & outlet chamber for a clear size of 600 x 600 x 900 mm including earthwork, PCC, brick work, flooring with concrete 1:2:4, plastering	Numbers	1.00	2,650	2,650.00

Detailed Abstract - Dispersion trench					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
	both inner and outer with necessary SRF cover slab etc., complete complying with standard specification as instructed or directed by the engineer in-charge				
8	Construction of inlet & outlet chamber for a clear size of 600 x 600 x 1100 mm including earthwork, PCC, brick work, flooring with concrete 1:2:4, plastering both inner and outer with necessary SRF cover slab etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Numbers	1.00	3,200	3,200.00
TOTAL					48,284.68
Say,					48,285.00

Soak pit – detailed estimate					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
1	Earth work open excavation in all soils and sub-soils and to full depth as may be directed except in rock requiring blasting inclusive of shoring shuttering, bailing out water wherever necessary and depositing the excavated earth with a lead of 10 mts. Within the compound in places shown by the departmental officers and clearing and levelling the site, etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Cubic metre	18.72	58.91	1,102.80
2	Cement concrete 1:5:10 (one cement, five sand and ten hard broken stone jelly) using 40 mm gauge hard broken granite stone jelly for bottom concrete including dewatering wherever necessary and laid in layers of not more than 15 cm thick well rammed, consolidated and curing etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Cubic metre	1.77	4,253.3	7,528.34
3	Supplying and fixing in position of RCC ring well of 4' dia with 1' height using cement mortar slush including lifting and fixing in position with proper gradient etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Numbers	8.00	1,200	9,600.00

Soak pit – detailed estimate					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
4	Manufacturing, supplying and fixing precast RCC slabs of following thickness in RCC 1:2:4 (one cement, two sand and four aggregates), using following HBGS jelly excluding cost of reinforcement steel in position but including cost of moulding charges, casting of slabs, finishing, curing and fixing in position in all floors etc., complete complying with standard specification as instructed or directed by the engineer in charge	Square metre	2.25	1,210	2,722.50
5	Supplying and fixing in position best quality PVC soil / waste pipes of various dia having 4 kg / sq.cm. pressure BIS mark and providing leak proof joints using PVC adhesives including fixing to the wall with special PVC / MS clamp, teak wood plugs, brass screws, etc., and making connection to all sanitary fittings, dismantling masonry / RCC works wherever found necessary and making the good dismantled portion to the original condition, including testing for any leakages, etc., complete complying with standard specification as instructed or directed by the engineer in charge (The PVC pipes should be got approved by the as instructed or directed by the engineering in-charge). The rate for earth work excavation will be measured and paid separately in the cases where the pipelines are proposed to be laid below				
A	110 mm dia PVC Pipe	Running metre	3.00	480	1,440.00
TOTAL					22,393.64
Say,					22,394.00

Abstract - New improved Septic tank					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
1	Earth work open excavation in all soils and sub-soils and to full depth as may be directed except in rock requiring blasting inclusive of shoring shuttering, bailing out water wherever necessary and depositing the excavated earth with a lead of 10 m within the compound in places shown by the	Cubic metre	166.72	58.91	9,821.48

Abstract - New improved Septic tank

Sl. No.	Description of Work	Unit	Qty	Rate	Amount
	departmental officers and clearing and levelling the site, etc., complete complying with standard specification as instructed or directed by the engineer in-charge				
2	Supplying and filling in foundation, basement, etc with filling sand in layers of not more than 15 cm thick well-watered, rammed and consolidated etc. complete complying with standard specification and as directed by as instructed or directed by the engineer in-charge	Cubic metre	6.05	1,489.2	9,009.66
3	Dismantling of brick wall and disposal with min lead of 30 m away from site as directed by the engineer in-charge, with required men and machineries etc., complete complying with standard specification and as directed by as instructed or directed by the engineer in-charge	Cubic metre	29.54	202.65	5,986.28
4	Dismantling of RCC Floor and roof and disposal with Min lead of 30 m away from site as directed by the engineer in-charge, with required men and machineries etc. Complete complying with standard specification and as directed by as instructed or directed by the engineer in-charge	Cubic metre	2.04	5,297.25	10,806.39
5	Plain Cement Concrete 1:2:4 (one cement, two sand and four hard broken stone jelly) using 20mm jelly for wearing coat including laying, compacting, finishing and curing, etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Cubic metre	0.22	5,735.42	1,261.79
6	Brick work in cement mortar 1:5 using best quality of country bricks of size 8-3/4" x 4-1/4" x 2-1/4" for foundation and basement including curing, etc., complete complying with standard specification	Cubic metre	14.00	5,135.5	71,897.00
7	Brick partition walls of 11.50cm thickness using best quality II class table moulded chamber burnt bricks of size 9" x 4-1/2" x 3" in cement mortar 1:3 (one cement and three sand) using hoop iron reinforcement if found necessary including curing etc. Complete and as directed by the departmental officers (Hoop iron reinforcement will be measured	Cubic metre	17.30	5,573.46	96,420.86

Abstract - New improved Septic tank

Sl. No.	Description of Work	Unit	Qty	Rate	Amount
	and paid for separately) in foundation and basement				
8	Manufacturing, supplying and fixing precast RCC slabs of following thickness in RCC 1:2:4 (one cement, two sand and four aggregates), using following HBGS jelly excluding cost of reinforcement steel in position but including cost of moulding charges, casting of slabs, finishing, curing and fixing in position in all floors etc., complete complying with standard specification and as directed (150mm thick)	Square metre	17.30	4,082.27	70,623.27
9	Plastering with cement mortar 1:5 (one cement and five sand), 12mm thick in all floors including curing etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Square metre	125.00	209.63	26,203.75
10	Supplying and painting the walls with two coats of cement paint as instructed by the departmental officers including preparation of surface curing, etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Square metre	55.00	115.5	6,352.50
11	Supplying and fixing PVC ventilating shaft of 110mm dia (having working pressure 4 kg. / sq.cm) with 3 m height including cost of PVC cylindrical cowl of best approved quality etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Numbers	2.00	70	140.00
12	Supplying and providing cinder or pebbles as filter media in the filter chamber of best approved quality as per standard specification etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Cubic metre	3.46	1,250.69	4,327.39
13	Manufacturing, supplying and fixing precast Reinforced Cement Concrete slabs of 50mm thickness in RCC 1:2:4 (one cement, two sand and four aggregates), using 20mm HBGS jelly excluding cost of reinforcement steel in position but including cost of moulding charges, casting of slabs, finishing, curing and fixing in position in all floors etc., complete complying with standard	Square metre	5.76	2,845.4	16,389.50

Abstract - New improved Septic tank					
Sl. No.	Description of Work	Unit	Qty	Rate	Amount
	specification and as directed by the engineer in-charge				
14	Supplying and fixing in position CI manhole covers with CI frames (heavy-duty) of size 60cm x 60cm of best approved quality as per standard specification etc., complete complying with standard specification as instructed or directed by the engineer in-charge	Numbers	10.00	2,200	22,000.00
15	Supplying and fixing in position best quality PVC soil / waste pipes of various dia having 4 kg / sq.cm. pressure BIS mark and providing leak proof joints using PVC adhesives including fixing to the wall with special PVC / MS clamp, teak wood plugs, brass screws, etc., and making connection to all sanitary fittings, dismantling masonry / RCC works wherever found necessary and making the good dismantled portion to the original condition, including testing for any leakages, etc., complete complying with standard specification as instructed or directed by the engineer in-charge (The PVC pipes should be got approved by the as instructed or directed by the engineer in-charge). The rate for earth work excavation will be measured and paid separately in the cases where the pipelines are proposed to be laid below				
A	110mm UPVC Pipe	Running Metre	18.00	480	8,640.00
B	160mm UPVC Pipe	Running Metre	4.00	549	2,196.00
16	Supplying and laying of UPVC Specials				
A	110mm UPVC Tee	Numbers	14.00	199	2,786.00
B	End Cap pf 110mm	Numbers	1.00	85	85.00
TOTAL					3,64,946.87
Say,					3,64,947.00

OpEx					
1	Provision for monthly maintenance and cleaning work in and around the Improved septic tank	Monthly	12	250	3,000.00
2	Containment desludging by once 3 years (Primary settler, Improved septic Tank & Soak pit)	Unit	2.00	2,500.00	5,000.00
3	Chlorine disinfection unit - Chlorine tablet cost by yearly once	Kg	2.00	530.00	1060.00
4	Cleaning of Filter materials and refilling it back to Anaerobic filter once in 5 years (Rs.30,000/5 = 6,000)	LS	1.00	6,000	6,000.00
Total					15,060.00

A5.12.1 Financials

Initial installation cost	The expenses made during the initial installation or renovation of the improved containment system are INR 4,40,000 to 6,40,000.
Operating costs	<p>This includes the cost of de-sludging the tanks once in every 3 years. The market rate for de-sludging in Trichy is INR 2,000 to 2,500 for every trip, based on the following assumptions:</p> <ul style="list-style-type: none"> ● Removal of blockages in the feeder line to the septic tank ● Not more than 3 lengths of the pipe joint during de-sludging ● Not more than 10 km (distance on road) between collection and disposal points <p>Provision for monthly maintenance and cleaning work in and around the improved septic tank is estimated as,</p> <p>Monthly = 12 x 250 = INR 3,000.00</p> <p>Containment de-sludging once in 3 years (Primary settler, Improved septic Tank & Soak pit), = 2.00 x 2500.00 = INR 5,000.00</p> <p>Chlorine disinfection unit - Chlorine tablet cost yearly once: 2.00 kg @ 530.00 = INR 1,060.00</p> <p>Cleaning of Filter materials and refilling the anaerobic filter once in 5 years (Rs.30,000/5 = INR 6,000)</p> <p>Total - INR 15,060</p>
Replacement cost	<p>This includes the cost of repairing or replacing or reconstructing the septic tank after its 15-year lifespan. Including the same minimum cost incurred during the improvement, it is estimated as INR 25,000 without any civil renovations. For de-sludging with proper safety protocol in case of leaks, inner plastering and a minimum amount for touch-up and painting, INR 1,83,000 is considered.</p> <p>So, the total Life cycle cost analysis for the Improvement septic tank is,</p> <ul style="list-style-type: none"> ● Min – 4,40,000 + 15,060 + 25,000 = INR 4,80,000. ● Max – 6,40,000 + 15,060 + 1,83,000 = INR 8,38,000.



City-Wide Inclusive Sanitation programme, Tiruchirappalli (CWIS-Trichy), Tamil Nadu supports the Trichy City Corporation (TCC) to make the improvements along the full cycle of sanitation. In particular, this programme will enable inclusive sanitation by mainstreaming gender, seeking improvements in service for the urban poor, increasing occupational safety, welfare for the sanitary workers and improvements in infrastructure.

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