GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

DEPARTMENT OF PUBLIC HEALTH ENGINEERING (DPHE)

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A Technology of Faecal Sludge Management in Sub-Urban Regions of Bangladesh

DPHE PUBLICATION
December 2014

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Published by:
Feasibility Study and Design Circle
Department of Public Health Engineering (DPHE)
Dhaka.

Feasibility Study and Design Circle, Publication # 1

December, 2014

ISBN: 978-984-33-8448-5

Lay out design and Drafting:
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Forwarding

Safe disposal of fecal sludge is one of the main components of improved sanitation in any country. Bangladesh though a densely populated country have very limited solutions of fecal sludge treatment. Considering the technical, environmental, social and financial aspects a treatment process of septic tank waste water and sludge has been implemented in 11 secondary towns (Pourashavas) by Department of Public Health Engineering (DPHE) under Secondary Towns Water Supply and Sanitation Sector (GOB-ADB) Project.

In the implemented faecal sludge treatment system, waste water is primarily treated in a septic tank then is pumped fed into reed beds where it is secondary treated. The system utilized the natural processes found at work around the roots of marshland plants known as reed plants. The bacteria living in aerobic conditions around the roots feed upon the harmful pathogens in the water, rendering the liquid healthier in the process. Septage sludge is treated by the bacteria living on the gravel surfaces. Oxygen from the atmosphere passes into the reed leaves, down their stems and along their hollow root system. It then passes out into the surrounding effluent aerating as it does so. The basic concept of the implemented technology is to collect septic tank water and sludge through vacutug and be conveyed to the sludge drying bed. Treated water would be discharged in agricultural land or sewer or water bodies after ensuring the waste water quality standard as mentioned in ECR, 1997. Co-composting of the solid digested portion would produce fertilizer for agricultural use.

This document contains the concept, design consideration, implementation methodology, treatment efficiency also the operation and maintenance procedure of the implemented faecal sludge treatment plant. This is just the beginning; there might be some technological modification and other suitable options for better treatment facility. Moreover, people's acceptability and area conditions are the other important issues had been taken in consideration during implementation.

I would like to express my gratitude to the Project Director, and the team of STWSSP for implementing this innovative and improved sanitation technology. I also gratefully acknowledge the contribution of Mr. Shishir Kumar Biswas, Assistant Engineer, DPHE for design and implementation of this plant. I would also like to thank DPHE field-level officers and the Mayors of the implementing Pourashavas for their valuable contribution.

18.12.2014

(Khaleda Ahsan)
Chief Engineer,
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1 Background

Faecal/septage sludge management concept is almost new in Bangladesh. In urban areas of Asia, Africa and Latin America, the excreta disposal situation has become dramatic: thousands of tons of sludges from on-site sanitation installations – so called faecal sludges (FS) – are disposed off daily untreated and indiscriminately into lanes, drainage ditches, onto open urban spaces, into inland waters, estuaries, and the sea. Though Dhaka is the capital city it has only a sewage treatment plant at Pagla with a 120 ML/d capacity and currently only 30% of the city area is served by the sewer system of which only 20% of the city population is connected with this. The facilities of sludge treatment plant in sub urban regions or secondary towns or Pourashavas are beyond imagination.

The Department of Public Health Engineering (DPHE) is the national lead agency provides drinking water supply, sanitation, drainage and waste management facilities in urban and rural areas excepting cities where WASAs operate. It has implemented the low cost technology of faecal sludge treatment including well equipped sludge transport system in some Pourashavas in Bangladesh (Figure-1). The aim of this initiative was the improvement of public health; Elimination of dumping of septic tank sludge into the environment; improving the functioning drainage system; Enhancing solids retention in septic tank to reduce solids accumulation in the drainage system and prevention of environmental pollution that is caused by effluents of not regularly de-sludged septic tanks. By product of the treatment, the dried sludge could be used as organic manure in agriculture and thus Pourashava's extra income source.

2 Prevailing arrangement of Sludge collection and Disposal in Pourashava

On-site sanitation practice is prevailing in the Pourashavas in Bangladesh. Domestic wastewater generally pre-treated in septic tanks and tank effluent is collected in soakage pits. Emptying of Sludge from Septic Tanks is done manually by employing private labors by individual household themselves and disposed of at places of convenience i.e. in drains, in dug holes, or open land without any treatment. Presently Pourashavas have very limited arrangements of centralized sludge collection and treatment for environmentally safe disposal of sludge collected from individual household's septic tanks. Sanitation, waste and sludge management are still neglected issues in Bangladesh. Peoples are not aware of improved sanitation system. They do not feel the essentiality of safe disposal of faecal sludge.

3 Objectives and criteria

In order to define objectives and criteria faecal sludge management in the urban and sub-urban areas of Bangladesh the following problems need to be addressed as well as causes of problems.

3.1 The Main problems in Pourashavas

- Risk for public health due to lacking treatment for safe disposal of sludge.
- Septage is handled without protection measures, dumped into the environment or in nearby dug holes.

- Septic tanks are often not emptied at required intervals. They become full with sludge and cannot retain the solids any more, which resulted in overflow of sludge from Septic Tanks which goes into nearby drains thus increased solids accumulation in the drainage system results, which contributes, in addition to environmental degradation and increased health risks, to blockage of drains and flooding.

3.2 The Causes of the problems

- Pourashava staff, comprising a sanitation officer does not have any role in sludge related affairs.
- The general population is not aware that septic tanks should be emptied more often to maintain their function.
- The Pourashava has no role in the emptying of Septic Tanks/removal of digested sludge from households' septic tanks. As such emptying of sludge from individual households is totally dependent on households.
- Pourashava has no proper existing treatment facility for safe disposal of sludge.

3.3 Principal objectives

Having identified the problems and their causes the objectives shall be as follows:

- Improvement of public health: Elimination of dumping of septic tank sludge into the environment.

- Improving the functioning of the drainage system: Enhancing solids retention in septic tank to reduce solids accumulation in the drainage system.
- Prevention of Environmental pollution that is caused by effluents of not regularly de-sludged septic tanks.
- Producing dewatered sludge that could be used as manure in agriculture.

3.4 Scope of Implementation

Keeping the available resources of sludge collection in view i-e two tractor driven Vacutugs of capacities 2 m^3 (2000 litres) and 0.7 m^3 (700 litres), the sludge management arrangements to be made should be consistent with sludge collection resources. These arrangements may not cover need of management of all faecal sludge produced in Pourashava but can provide a facility that could be extended in future.

At the same time, the experience with the initial technology implementation will help to plan the further extension of facility on a more precise data basis. Positive experiences will help to convince the stakeholders of the success of proposed measures, as they would actually experience the positive impacts results due to initial intervention.

Based on sludge collection capacity that would be available with provision of i-e two tractor driven Vacutugs of capacities 2 m^3 (2000 litres) and 0.7 m^3 (700 litres) and two trips of Vacutugs to disposal site considering the distance of sludge disposal site from Pourashava center (i-e 2.5 km), the sludge quantity that could be collected using provided machinery would be 5.4 m^3/day i-e emptied sludge of around two septic tanks per day.

4 Technical Options for Sludge Treatment

In the Pourashavas, where Septic Tanks are predominant type of on-site sanitation treatment, the proposed treatment scheme will provide comprehensive treatment of septage and it's by products i-e (biosolids and liquids).

Septic Tanks provide the primary treatment of sludge through gravity settling of solids under anaerobic conditions. Such primary treatment produce less sludge than aerobic treatments (e.g. from trickling filters, activated sludge) and anaerobic sludge also dries better and results in less odour as it is more stabilised.

Though characteristics of digested sludge produced in septic tanks vary from location to location, depending on habits and climate, the typical characteristics of digested sludge produced in septic tanks can be described as follows-

Characteristic	Typical Range
COD (mg/l)	3,000 -10,000
BOD/COD	0.2 – 0.1
NH_4 – N (mg/l)	300 – 1,000
Total Solids (TS)	0.5 – 3.0 %
Faecal Coliform (Fc)	Uncountable
Helm. Eggs (nos./l)	(+/-) 4,000

All organic degradation process produces sludge. As mentioned above, Sludge of Septic Tanks has a total solid content of 0.5 to 3 % and cannot be transported easily with simple equipment. Apart from this, sludge is contaminated and occupies large volumes for storage. Therefore, to reduce volume it is necessary to dry sludge (dewater) before further use or dumping.

There are several technologies involve with drying of sludge. These can broadly be classified under two categories i-e

- Natural processes
- Mechanical processes.

The natural processes include Sludge drying beds; whereas the mechanical processes include centrifugal treatment, filter presses, heat treatment (incinerators) etc.

The mechanical processes are generally expensive, involve energy (electricity/fuel) and also need certain degree of expertise for operating and maintaining the facility, where as the natural processes are less expensive to operate and maintain. The prime advantages of mechanical processes over natural processes are requirement of less area for installation of facility and independence from weather.

If land is available the natural processes are always be a preferred choice because of less cost of operation and maintenance, minimum energy cost if any, as well as no special expertise are required for operation & maintenance of facility. The problem related to impact of weather i-e rains can be address by either providing cover over the facility or stopping the operation of facility in days of rains.

In most of the Pourashavas of Bangladesh, managing land is possible for construction of sludge treatment facility and therefore natural process i-e sludge drying beds is given preference over Mechanical processes.

5 Sludge Drying Beds

5.1 Types of Sludge Drying Beds

Sludge drying beds can be

- Conventional Sludge drying beds (unplanted & planted)
- Paved drying beds
- Wedge-wire drying beds
- Vacuum assisted drying beds

Among the above listed types of drying beds, conventional beds are the simplest. Conventional Sludge drying beds simply are impermeable beds filled with different layers of gravel and sand. Sludge drying beds are one of the simplest and oldest techniques for sludge dewatering. The Sludge drying beds can either be unplanted or planted (i-e reed beds/vertical wetlands, as they are generally described).

The main features and working principals of two types of Conventional Sludge drying beds are described here.

- ➢ Unplanted sludge drying beds
    - Design comprises impermeable beds filled with different layers of gravel and sand.

- Require desludging after every cycle of drying (manpower required) i-e every 7-10 days.
- Require frequent replacement of at least top layer of filter media.
- Required further treatment (composting or long term i-e 6-7 months storage of dried sludge produced from sludge drying beds).

➢ Planted sludge drying beds

- Design similar to un-planted drying beds. Except for planting of reeds.
- Do not need desludging after every cycle of sludge loading as Porosity is maintained by the root systems of the plants. Depending of size of beds, the de-sludging may require after every few years.
- Sludge is transformed into biomass (plants) and can be harvested directly for use in agriculture or safe disposal without any further treatment.

5.1.1 Unplanted sludge drying beds

Unplanted sludge drying beds are simple sand and gravel filters on which batch load of sludge are applied for dewatering mainly by percolation through filter media and to some extent by evaporation. Drying time in unplanted sludge drying beds is about 7-10 days depending on prevailing ambient temperature. In unplanted sludge drying beds, it is necessary to desludge dried sludge before fresh sludge can be applied. Moreover, the dried sludge produced in unplanted sludge drying beds needs further treatment (composting) or prolong storage before it can be used in agriculture. Frequent desludging may require replacement of filter media in the top layer.

5.1.2 Planted Drying Bed

As in unplanted sludge drying beds, planted beds consist of an impermeable shallow pit filled with different layers of coarse to fine filter media. However, unlike unplanted beds, planted drying beds do not need desludging before each new application / loading of sludge as root system of the plants maintains the permeability of the beds. The sludge can be added intermittently every 7-15 days and only need to be removed every 5-10 years depending on provided depth of beds and percentage of solids in applied sludge. The pictures of the constructed FSTP at different Pourashavas are shown in Figure-2a, 2b and 2c.

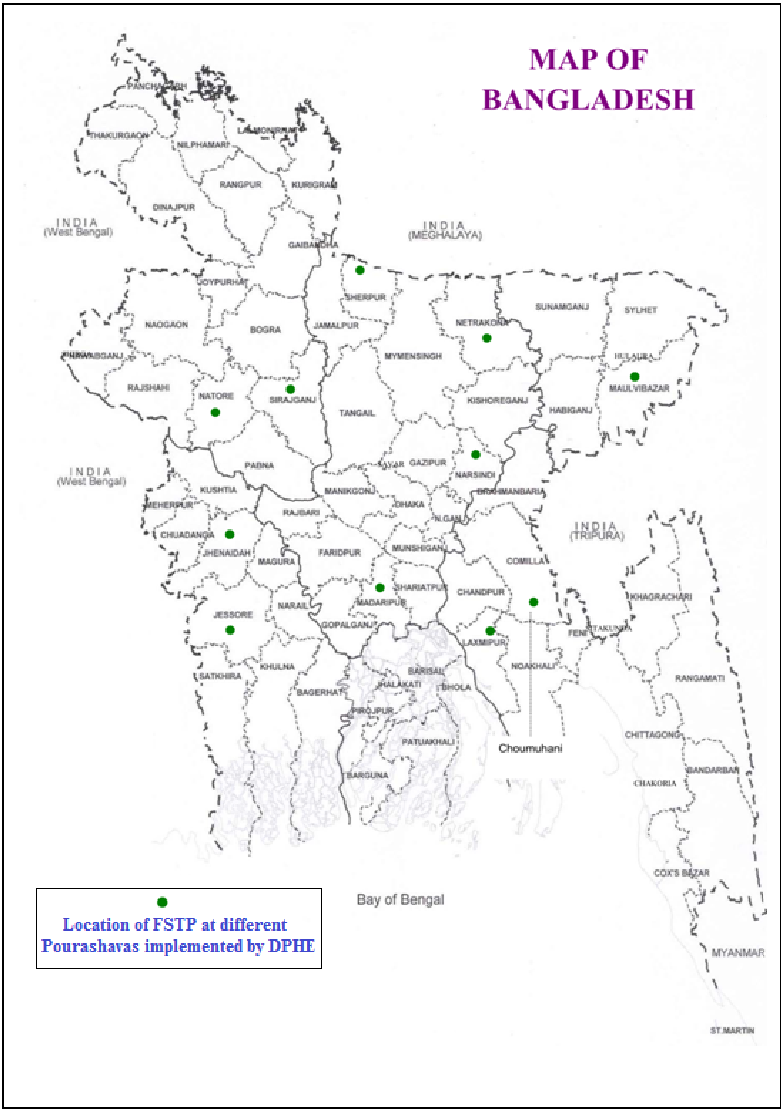

Figure-1: Location of the constructed FSTP at different Pourashavas in Bangladesh

Figure-2a: Planted sludge drying bed of FSTP at Narsingdi Pourashava, Bangladesh

Figure-2b: Planted faecal sludge drying bed of FSTP at Lakshmipur Pourashava, Bangladesh

Figure-2c: Percolate collection pond of FSTP at Sirajganj Pourashava, Bangladesh

6 Implemented Technology

Considering merits and demerits of the different technologies available for sludge drying, the planted sludge drying bed technology were adopted for implementation of faecal sludge management at different Pourashavas in Bangladesh. Considering additional cost for covering the beds and application of direct solar flux for evapotranspiration, the constructed planted sludge drying beds were without cover.

The preference of planted sludge drying beds over unplanted sludge drying beds for adoption was made for following reasons:

- The dried sludge produced from these beds shall not require further treatment for its disposal.

- Efficiency to dewater wet sludge to a dry matter content of more than 40%, while achieve volume reduction up to 98%.
- De-sludging of beds require only after considerable time (as mentioned in preceding paragraphs).
- Reed beds are odour free as the sludge is kept aerobic.
- Required specie of reeds for planting in drying beds is abundantly available in Bangladesh.
- No electricity is required for the plant itself for operation.
- Exhibit good chemical and biological contaminants removal efficiency

7 Treatment Efficiency of Planted Reeds drying beds

Of the entire solids load discharge onto the beds, about 50% are retained on the bed surface as biosolids, 10% are contained in the percolate and 40% are lost through degradation of organic material yielding water and CO_2. Of the water brought onto the beds with sludge, about one third is evapotranspirated and two thirds are drained through peculation via filter media while accumulated biosolids retain about 2% of water. Regarding Nitrogen that is loaded with sludge onto beds, 50% are accumulated in the biosolids and 25% each leave the system through volatilisation and in the percolate.

The over all efficiency of planted drying beds for removal of nematode eggs is about 98-99%. Considering normal nematode eggs concentration in raw septage (i-e raw sludge of septic tanks) as 40 eggs/gTS, with above stated efficiency the concentration of nematode eggs in accumulated dried sludge shall be about 2eggs/gTS, that is within acceptable international standard of 8 eggs/gTS . As such use of accumulated biosolids (dried sludge), produced from drying beds, in agriculture shall not result in risk to public health.

8 Design Considerations and Size of the drying bed

8.1 Main-components:

- Filter media i-e Different layers of coarse gravel, gravel, sand.
- Drying Beds
- Under drain piping in the bed bottom
- Ventilation pipes
- Sludge Loading & inlet pipes
- Sludge unloading chamber
- Planting of Phragmites (Karka) reeds.
- Percolate collection pond
- Access road for tractor with vaccum pump
- Portable Diesel water pump

8.1.1 Filter media

It is necessary that filter media should be thoroughly washed before placing in beds. Washing of media prevent clogging of filter media pores, especially during start up phase.

- Large gravel (d=20 -40 mm): 35 cm layer thickness
- Fine gravel (d=5-10 mm): 15 cm layer thickness
- Sand (d = 0.85 – 1.3 mm): 20 cm layer thickness

8.1.2 Drying Beds and bed sizing

Drying beds are shallow impermeable pits/beds made with RCC walls and with sloping 30cm thick clay bed lined with 1:2 cs pointed flat bricks and NCF over the brick soling. Sizing of beds shall be based on requirement of handling/ treatment of Sludge.
For the treatment plants constructed by DPHE, The following consideration had been taken into account in sizing of the beds:

Total Solids concentration in Septic Tanks Sludge	3%
Per Year Solids Loading Rate	50 to 150 kgTS/m^2/Year
Thickness of applied sludge	75mm – 200mm
Sludge collection capacity	5.4 m^3/day
Period (days) of loading	2-5 days
**Rest Period of sludge in beds	9-15 days

<u>Sizing of beds (typical for all two beds)</u>

*Volume of sludge loading in 4 days	21.6 m^3
Required Area with 15 cm layer of sludge	21.6/0.15 = 144 m2
Adopted dimensions	length 16m width 9m provided area = 16 x 9 = 144 sq.m

The minimum wall height The minimum wall height	1.9 m above bed level at highest point of bed. 2.267 m above bed level at deepest point of bed
Height of walls was made variable to accommodate bed slope and to keep top level of walls same along periphery of pond	
Beds were provided with 2% cross slope for drainage of percolate from loaded sludge. Conservative slope was provided to achieve maximum retention time of percolate to remain in beds. Retention of percolate in beds increase removal of faecal coli form from percolate.	

*Area requirement was calculated for volume 21.6m^3, the middle figure of volume range planned to be applied onto beds.

** Rest period range is given with taking account of rain days lost.

In total two beds were provided at treatment facility. Two beds will be used for alternate loading of sludge to allow for adequate resting period. Brick pavement was provided on surface space in between two beds as well as along outer walls.

General plan of provided beds is presented in Figure-3.

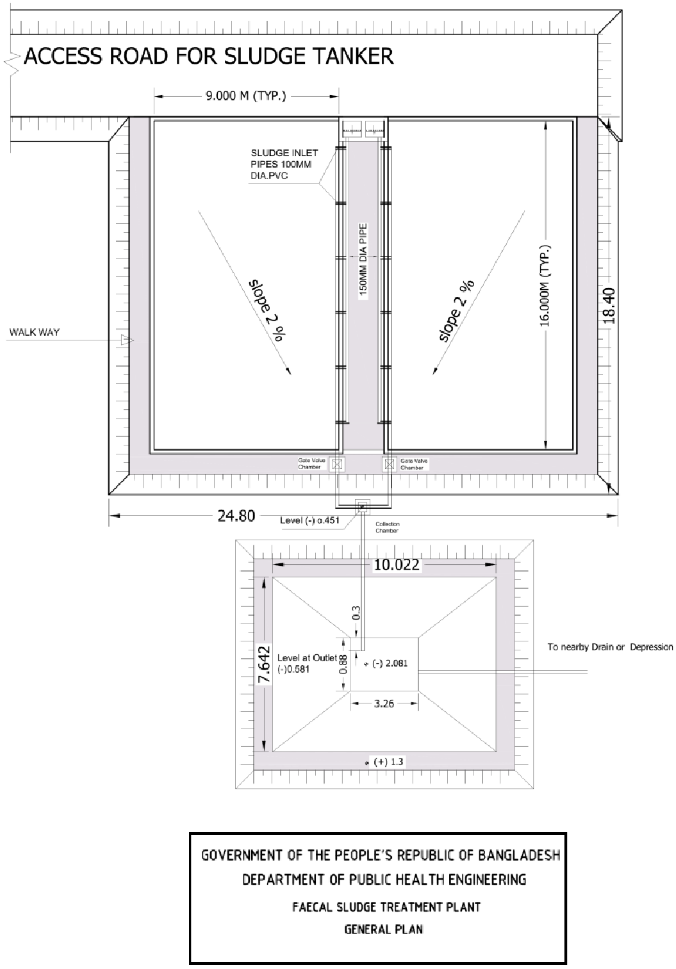

Figure 3: General plan of the beds of Faecal Sludge Treatment Plant

8.1.3 Drainage and under drain piping

A system of perforated pipes is needed to receive decanted water from applied sludge that seeps through the layers of sand and gravel into the under drains and finally transported to disposal location.

In each of two beds, six number Perforated 100 mm diameter PVC drainage pipes were provided along width of bed at spacing of 2.667m. The pipes along their length were sloped at 0.98%. The 100mm diameter pipes than connected to a 150mm diameter perforated PVC pipe that was laid at 1.74% slope towards discharge point. From discharge point, the percolate from drying beds goes to nearby polishing pond through 150 mm Φ PVC pipe.

The perforations in 100mm & 150mm diameter PVC pipes were made by drilling 12mm diameter holes at c/c spacing of 34.6 & 35.9mm respectively. Figure-4 Show the layout of drainage piping.

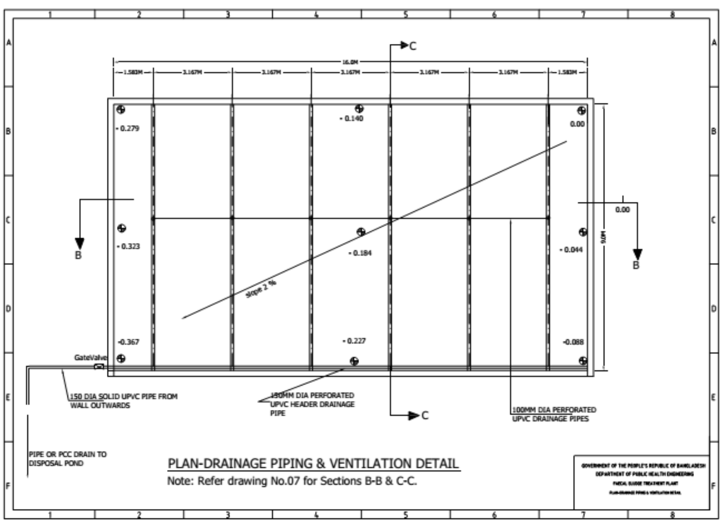

Figure 4: Layout of drainage piping of Faecal Sludge Treatment Plant

8.1.4 Ventilation pipes

Natural drought ventilation is required to avoid anaerobic conditions in root zone and hence the damage to reeds health. A ventilation system allowing for natural bottom aeration is, therefore necessary, particularly when dealing with anaerobic sludge.

To meet ventilation requirement, in each of the two beds, eighteen number 150mm dia PVC ventilation pipes were provided to create passive aeration at bottom of beds. Three ventilation pipes were connected to each drainage pipes with uequal tee (100 x 100 x 100 mm size) and an enlarger of size 100 x 150 mm. The top of ventilation pipes are fixed about 3.44m above top of filter media. CC block supports were provided to hold ventilation pipes in position. A canopy at top of each ventilation pipe was provided to prevent ingress of dirt and rainwater into ventilation pipes. Figure-5 Shows the typical detail of ventilation pipes.

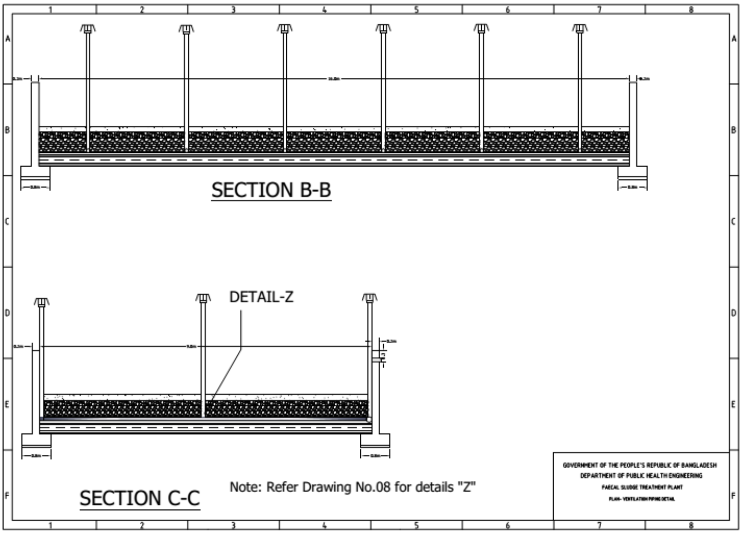

Figure 5: Typical detail of ventilation pipes of Faecal Sludge Treatment Plant

8.1.5 Sludge loading/feed pipe and inlet pipes

From access roads, the septage sludge from vaccum tug is discharged into RCC sludge unloading chambers. From chambers, the loaded sludge goes into beds via 15cm Φ. PVC feed pipe and through inlet pipes. The feed pipe was sloped at 1.74 % along length of pits/beds. The sludge than loaded onto beds through six inlet pipes provided for this purpose at each pit/bed. For easy and uniform distribution of sludge of beds, it is proposed that removable flexible hose pipes shall be used for distribution of sludge over area of bed by connecting hose pipe to inlet pipes.

8.1.6 Sludge unloading chamber

To avoid splash on bed and to screen the sludge load, a sludge unloading tank was provided at head of bed. The chamber was provided with a bar screen to trap any bigger object before finding their way into sludge feeding pipe.

8.1.7 Reeds

There were several types of reeds and wetland plants that had been used in constructed planted sludge drying beds. The species that had successfully been tried in drying beds include:

Phragmites karka – Nalkhagra

Location:

Chittaging Hill Tracts,

Sundarban,

Tangua Haor (Dharmapasha & Tahirpur upazilas, Sunamganj)

Scripus maritimus – Cheasra (mainly aquatic weeds)

Location:

Wet agricultural lands

Typhaceae- Hogla (Elephant grass)

Location:

Char Area, Patuakhali, Barguna

For the constructed faecal sludge treatment plants, Phragmites Karka (reed) and Napier grass were proposed for planting. The selection of Phragmites Karka and Napier grass were made mainly for their availability in Bangladesh. In addition to that those are tough adaptable plants, which can grow in polluted waters and find sustenance in sludge. This reeds have a voracious appetite for water. The plants are tolerant to low oxygen levels. In favourable conditions those exhibit fast growing rate, newly planted reeds form dense standing crop in about 9 months to their full height of about 2.5 m. Phragmites Karka and Napier grass hold themselves in the soil through roots and rhizomes, an intricate network of underground stems. New plants in turn will sprout from these stems. These rapidly growing roots provide air passage through the sludge which in turn provides a host area for many biological communities to develop and continue to mineralize the sludge.

The reeds were planted in sand layer at interface with pea gravel layer at a c/c spacing of 0.3 m. i-e about 1510 plants were planted in each of the two beds provided at facility. After plantation of reeds, the beds were flooded with water for several weeks to encourage plant development.

8.1.8 Percolate collection pond

A clay lined earthen pond was provided for collection and polishing of effluent (percolate) from drying beds. The pond shall usually works as facultative pond and sized accordingly. The effluent storage capacity of provided pond is 18.09 m^3 which was estimated on the basis of 5 days retention time in pond for effluent generated at the highest loading of septic sludge onto the beds. The provided pond is a rectangular truncated trapezium with 1.5m depth & long and required short lengths of sides at top of pond for storage volume is about 10.9 m and 8.5 m respectively. Provided side slopes was 1:1. A free board of 2.3m considered and maintained as discharge pipe from beds enters pond at about 1.4 m below FGL. Further to that a 0.6m high protection embankment was provided for pond to prevent surface run off from entering the pond. The overall dimensions of as follows:

Top longer length	= 10.9	m
Top shorter length	= 8.5	m
bottom longer length	= 3.3	m
bottom shorter length	= 0.9	m
Over all depth	= 3.8	m
Side Slope H:V	1:1	
Length: width ratio	2	

8.1.9 Access Road

An access road of 4.0 m width and top made of 125mm thick brick on edge laid over 75mm thick flat bricks was provided for tractors carrying vacutugs for unloading collected sludge into sludge unloading chamber for consequent loading onto beds through sludge unloading drains.

8.1.10 Protection against surface run off

To safe guard against surface run off, RCC walls of beds were extend 1.2 meter above finished ground level all along periphery of pits/pond system.

8.1.11 Portable Diesel water pump

Provision of one 0.5HP portable diesel operated water pump with 12mm pipe of 30m length was made for application of collected effluent onto beds for watering of plants in case of need.

9 Commissioning and operation design

9.1 Startup design

After planting of reeds, the beds were be flooded with water for 2-3 weeks to enable plant roots and rhizomes to establish. For first full year of operation, the beds should be loaded at a conservative loading rate. For beds, two days sludge loading i-e 10.8m^3 with 75mm thick sludge layer is recommended with rest period of 12 days. Considering two beds, the sludge loading and rest cycle was maintained as 4 days of sludge loading per week with 12 days rest period for each bed. As such, each bed was loaded with sludge for about 26 times in one year. At this rate, solids loading on each bed were around 56kgTS/m^2/year as calculated under:

At Start up (one year)				
Loading/bed	2	days		
2 days volume of sludge @ 5.4 m^3/day	10.8	m^3		
Rest period	12	days		
Sludge loading (2 days per 14 days)/bed				
Year days	365			
Loading cycles/year	26.07	say	26	loading per year

At Start up (one year)				
Area of Bed	144	sq. m		
Layer thickness	75	mm	or	7.5 cm
Thickness of loaded sludge in one year	195	cm		
Sludge loading Kg TS/m^2	55.71	say	56	Kg TS/m^2

This conservative sludge loading rate shall allow the root system to become fully established throughout the bed.

During start up phase, it is very important that the sand remain moist at all times. To achieve this some times, especially in dry season, it may be needed to supplement the sludge loadings with plant effluent watering to prevent wilting of reeds. Additional water requirement should not be met by increasing thickness of sludge layer loading.

At the start-up phase, percolate (effluent) storage Pond initially be filled with water, either from a river or lake, pond or a well. Seeding of pond with algal rich water is not generally necessary, although if a source of such water is readily available locally, it may be used to seed the pond and so speed up development of bacterial and algal populations. The filled up pond will left with water for 10-20 days, before the introduction of effluent from beds.

9.2 Normal operation

The start-up phase normally complete in about 9 months to one year, some times less is required depending upon plant growth. If there is vigorous reed growth throughout the bed before completion of one year, the start-up phase can be shortened and sludge loading at normal rate may begin earlier. During period after start-up phase, 4 days sludge loading/bed i-e 21.6m^3 with 150 mm thick sludge layer is recommended with rest period of 10 days. As such, each bed shall be loaded with sludge 26 times in one year. At this rate, solids loading on each bed shall be around 112 kgTS/m^2/year as calculated under:

At Normal operation (one year after start up)				
Loading/bed	4	days		
4 days volume of sludge @ 5.4 m^3/day	21.6	m^3		
Rest period	10	days		
Sludge loading (4 days per 14 days)/bed				
Year days	365			
Loading cycles/year	26.07	say	26	loading per year
Area of Bed	144	sq. m		
Layer thickness	150	mm	or	15 cm
Thickness of loaded sludge in one year	390	cm		
Sludge loading Kg TS/m^2	111.43	say	112	Kg TS/m^2

After another one year, this rate can further be increased by allowing about 188mm thick sludge layer per application with rest period of 9 days as calculated under:

At Normal operation (After one year of normal operation)				
Loading/bed	5	days		
5 days volume of sludge @ 5.4 m^3/day	27	m^3		
Rest period	9	days		
Sludge loading (5 days per 14 days)/bed				
Year days	365			
Loading cycles/year	26.07	say	26	loading per year
Area of Bed	144	sq. m		
Layer thickness	187.5	mm	or	18.75 cm
Thickness of loaded sludge in one year	487.5	cm		
Sludge loading Kg TS/m^2	139.28	say	140	Kg TS/m^2

The rest period does not include days when the beds subject to rain. The rest period shall be adjusted by adding the number of rain days. Similarly during severe winters it may be needed to increase the duration of rest period by few days. However adjustment in rest period is entirely dependent on degree of dewatering achieved.

9.3 Sludge removal

With proper operation as stated, the provided beds should not require any sludge removal for 8-10 years. When the depth of dried sludge gets within one foot of the top of periphery wall, the beds should be taken out of service, dried and cleaned. The bed to be cleaned should not have sludge applied after plant growth has started in the spring. The bed should be allowed to dry (for a period 6 to 9 months) to the point that the reeds wilt from lack of water. The bed then may be excavated manually. Any sand removed with the sludge need to be replaced by fresh sand. Much of the original rootstock will remain for re-growth of reeds when application of sludge restarted. Some time planting of new reeds may be needed.

The time for drying of sludge after stoppage of sludge loading plus re-growth of reeds will be about 1.5- 2 years. It is therefore after stoppage of operation of 1st bed at 8th Year of operation, the sludge loading shall be started on 2nd bed. During that period the 1st bed will again become ready to receive sludge, and hence the process of de-sludging of 2nd bed shall follow the operation as 1st bed i-e drying for 6-9 months and after removal of dried sludge allowing time for re-growth of reeds.

10 Cost considerations

Investment costs of sludge drying beds are moderate as land prices are low in most of the Pourashavas and filter material (gravel/sand) is locally available. Operation costs are low as no energy or complicated equipment is required except for 0.5HP water pump. The cost of constructing above detailed facility, excluding land cost, is about 3.5 million Taka.

11 Operation & Maintenance

No special expertise is involved in O & M of facility. Only informed man power is required for O & M. The total man power that is required to operate & maintain the treatment facility comprise from 2-3 persons. During sludge loading onto beds, it is found that 1-2 additional person (s) is/are sufficient in addition to person accompanying the tractor (i-e driver of tractor). During start-up phase close watch of reeds growth shall be required. The person responsible for sludge application onto beds should be educated about importance of maintaining recommended sludge thickness during application.

In addition, it is recommended that a log book should be kept to document reed bed operation including following simple information:

- Date of loading
- Amount of sludge applied
- Thickness of applied sludge layer
- Observation on plant growth
- Verification of leachate drainage
- Any maintenance performed and any other relevant observations

Log book should bear signature of person entering the information.

Description of operations regarding specific activity is provided in following paragraphs:

11.1 Application of sludge

The distribution of sludge onto surface of drying bed, for maintaining uniformity, is recommended by moving hose-nozzle round the bed area of unit. The application rates of sludge in recommended thickness need to be carefully monitored, especially in start-up phase. Sludge application of required layer depth should be made from one inlet pipe at a time, starting from the farthest inlet pipe, by plugging other inlet pipes.

Sludge rest times recommended are provided as guide, in case of occurrence of rain during rest period, the rest period need to be extended to compensate for days lost due to rain.

In winters, although plant growth may slow down, the roots growth continues through the new sludge that is loaded onto the bed. It is therefore possible that sludge loading shall continue in winter, may be, with increase in resting duration.

11.2 De-sludging

De-sludging at appropriate time (when beds filled up to with-in 30cm from top of wall i-e after 8-10 years operation), shall be done manually with protective gear (gloves and long boots) for labour engaged in de-sludging. After the sludge residue is removed, a thin layer of fresh sand is to be added, and the reeds shall be allowed to regenerate from the remaining rhizomes (root system).

Any bed to be cleaned should be put off of operation and shall not have sludge applied after plant growth has started in spring. The bed should be allowed to dry, for about 6-9 months, to the point that the reeds wilt from lack of water. The ideal period to empty the bed (s) is between mid July and late August. This is to benefit both of the high evaporation in summer and not to undermine the re-growth of reeds in the beds emptied before winter.

11.3 Reeds maintenance

At start-up, it is required to monitor the health of reeds. During start-up phase it is necessary to keep sand layer of filter media moist at all times. For this purpose occasionally the beds need to be watered with plant effluent. In case of observance of reeds wilting (turning yellow) at any time (especially in summers), the effluent need to be ponded to a level just below the stored sludge layer for some days, normally 4-6 days ponding restore reeds plants health and then effluent shall be allowed to flow off.

On annual basis (during the late fall to early winter after the reeds have turned brown), it is recommended to cut the reeds to within 30cm of the sludge surface. The cut material shall need to be removed from the bed to prevent accumulation of plant debris and to provide room for new growth in spring. Cutting of reeds shall be done by hedge clippers. Harvested plant material is then burned.

Summer time operation of the reeds beds require regular attention to plant growth to assure that the reeds are getting enough moisture. If the sludge application rate is not enough to keep the sand layer moist, then the plant effluent need to be applied between sludge loadings. This is especially important during the first year of operation i-e during start-up phase.

Infestation with aphids could slow the establishment of a healthy stand of reeds during start-up period. Both biological and chemical methods could be used to control aphid population. Aphids can be successfully controlled by using introducing Lady Bugs at a rate of one gallon per 10,000 sq.ft i-e 0.16 gallon/per bed.

11.4 Handling of dried sludge and percolate

When beds are emptied, the sludge residue (dried sludge) shall have a consistency of damp soil which makes it easy to transport and spread onto agricultural land or to use as landfill cover. Faecal sludge treatment plants of sludge drying beds are provided at different Pourashavas to handle faecal sludge of septic tanks, possibility of presence of heavy metals concentration in sludge is about nil. It is therefore, considering the treatment efficiency of drying beds, emptied sludge can safely be used for agriculture without any further treatment such as composting. As such dried sludge from beds shall provide a valuable resource that can be, with proper planning, commercialise by Pourashava to raise funds.

The experience and laboratory test reports of the effluent of the constructed planted septage sludge drying beds indicate satisfactory performance of planted drying beds regarding contaminants (e.g BOD_5, COD, TSS, TDS, Feacal coliforms and Ammonia Nitrogen) removal efficiencies. Those are provided here:

Septic Tank Raw Water Quality

Si. No.	Water Quality Parameters	Unit	Cons. Present	ECR 1997		
				Discharge in Inland Water	Discharge into Public Sewer	Discharge on Irrigated Land
1	pH	-	7.34	6-9	6-9	6-9
2	Faecal Coliform (FC)	mg/L	160000	-	-	-
3	Chemical Oxygen Demand (COD)	mg/L	28100	200	400	400
4	Biochemical Oxygen Demand (BOD)	mg/L	5000	50	250	100
5	Total Suspended Solid (TSS)	mg/L	59036	150	500	200
6	Total Dissolved Solid (TDS)	mg/L	450	2100	2100	2100
7	Ammonia Nitrogen (NH_3-N)	mg/L	153.5	50	75	75

FSTP Treated Water Quality at Wet Season

Si. No.	Water Quality Parameters	Unit	Cons. Present	ECR 1997		
				Discharge in Inland Water	Discharge into Public Sewer	Discharge on Irrigated Land
1	pH	-	8.09	6-9	6-9	6-9
2	Faecal Coliform (FC)	mg/L	100	-	-	-
3	Chemical Oxygen Demand (COD)	mg/L	45	200	400	400
4	Biochemical Oxygen Demand (BOD)	mg/L	12	50	250	100
5	Total Suspended Solid (TSS)	mg/L	17	150	500	200
6	Total Dissolved Solid (TDS)	mg/L	244	2100	2100	2100
7	Ammonia Nitrogen (NH_3-N)	mg/L	1.69	50	75	75

FSTP Treated Water Quality at Dry Season

Si. No.	Water Quality Parameters	Unit	Cons. Present	ECR 1997		
				Discharge in Inland Water	Discharge into Public Sewer	Discharge on Irrigated Land
1	pH	-	8.44	6-9	6-9	6-9
2	Faecal Coliform (FC)	mg/L	900	-	-	-
3	Chemical Oxygen Demand (COD)	mg/L	148	200	400	400
4	Biochemical Oxygen Demand (BOD)	mg/L	12.5	50	250	100
5	Total Suspended Solid (TSS)	mg/L	57	150	500	200
6	Total Dissolved Solid (TDS)	mg/L	1447	2100	2100	2100
7	Ammonia Nitrogen (NH_3-N)	mg/L	1.23	50	75	75

In spite of the high contaminants removal efficiency of reed beds, it is desirable to further polish the percolate by storing for 5 days in pond before final disposal to environment. For this purpose provision of one pond is made for the facility. The stored effluent will discharge from pond to near by field or some existing depression. An earthen channel shall need to be excavated, if no existing out let drain or depression exists on site for conveyance of pond effluent to desired location.

11.5 Monitoring of dried sludge and percolate (effluent) quality

The continuous monitoring of dried sludge and percolate (effluent) of drying beds is needed for assessing the performance of drying beds. For this purpose monthly samples of dried sludge and effluent should be collected at site for laboratory tests regarding following parameters:

11.5.1 Dried sludge

- Total solids concentration (TS)
- NH_4-N
- Feacal coliforms (FC)
- BOD_5

Monitoring of heavy metal contaminants is not proposed as drying beds are handling septic tanks sludge and septic tanks in Pourashava is receiving discharge from toilets only.

11.5.2 Percolate (effluent)

- Faecal Coliform (FC)
- TDS
- TSS
- NH_4-N
- COD
- BOD_5

The monitoring of percolate (effluent) for above given parameters is proposed to assess the utility of received percolate for subsequent use according to its quality.

Samples of percolate should be collected at point of its discharge from beds as well as at discharge point from storage pond.

12 Conclusions

The considerable positive impact found in environmental point of view due to implementation of fecal sludge treatment plant. Before operation of this plant constructed at different Pourashavas it was quite common to see septage waste in open drain. House owner used to connect their septic tank discharge line to the open drainage system which convey the waste to the water bodies and pollute those tremendously. Since there was no safe dumping spot in the Pourashava, people used to remove septic tank waste to the abandoned places or pit in the night. This experience was not only harmful for the human health. It increased the possibility of ground and surface water contamination also polluted the air spreading stench. Now the peoples of the Pourashava are enjoying the fresh environment. New implementation of this treatment plants in the other Pourashavas step by step, proper operation and maintenance of this plant can initiate a new era of improved sanitation in Bangladesh.